CIRP – SMS Steering Model Workshop

ADCIRC – Modeling Strategy and Example Applications

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ADCIRC Strategy

- Provide localized grid resolution to resolve the pertinent flow physics so that accurate solutions result
- Define domain boundaries that are hydrodynamically simple and away from the study region
- Maintain a state-of-the-art code that
  - Is fast and can handle very large and flexible grids
  - Has many features and interfaces
  - Evolves with increasing grid resolution, better discretization algorithms, better algebraic solvers and computer architectures

ADCIRC Example Applications

- Southern Louisiana Storms Surge Model
- Western North Atlantic Tidal Model and Tidal Data Base
- ADCIRC example applications worldwide

Southern Louisiana Storm Surge Model

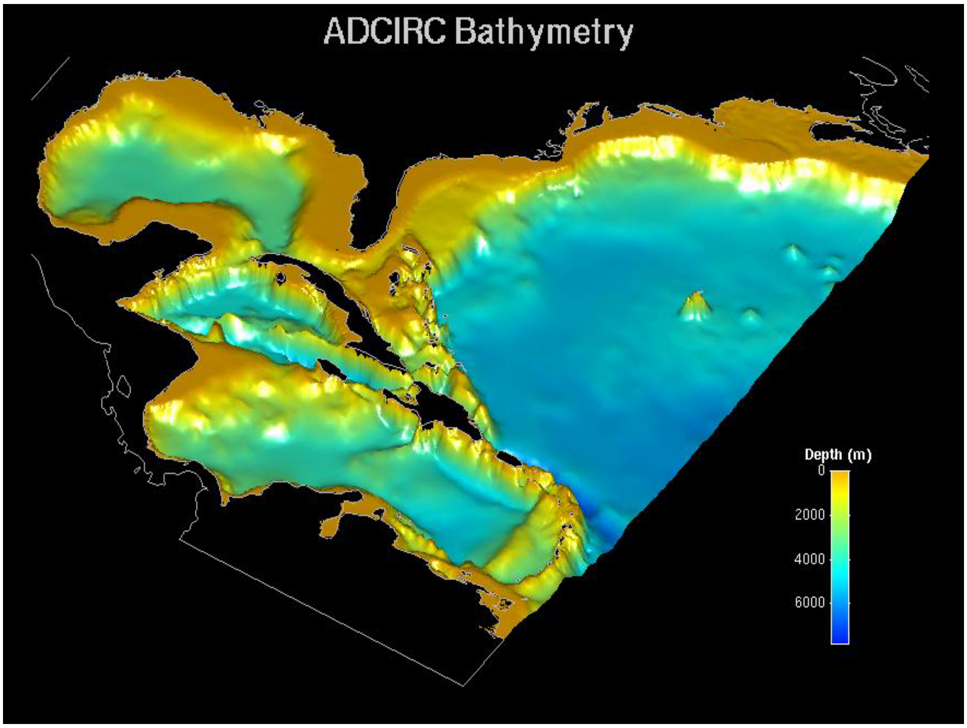
- ADCIRC application to compute tides and hurricane storm surge in Southern Louisiana
- Forcing includes tides, tidal potential, winds, atmospheric pressure, and riverine flow
- Region is low lying and is subject to extensive overland flooding and includes many rivers, channels, lakes and an extensive levee system
- Gulf of Mexico is also subject to hurricane forerunner associated with resonant excitation of the Gulf

Modeling Strategy – Domain Definition

- Application of very large computational domain in order to simplify the specification of boundary conditions
- Model domain incorporates the western North Atlantic, Gulf of Mexico and Caribbean Sea
- Advantages for computing tides
  - Response for tides is simple and varies slowly in space in the deep Atlantic
  - Global models and satellite data for tides is more reliable in the deep Atlantic
  - Boundaries are situated outside of resonant basins (Gulf of Mexico and Caribbean Sea)
  - Nonlinear tidal species exist mainly on the shelf where they are generated and largely trapped

Modeling Strategy – Domain Definition

- Advantages for computing hurricane storm surge
  - Surface response for a hurricane in the deep Atlantic is simply an inverted barometer corresponding to the atmospheric pressure deficit
  - Surface response on the shelf, adjacent to land, and within resonant basins is spatially complicated
- The large domain strategy correctly captures
  - Basin to basin interactions
  - Basin to shelf dynamics
  - Shelf to adjacent coast/land dynamics
- To simplify boundary conditions is significantly better than trying to build complicated physics into the boundary conditions



Modeling Strategy - Discretization

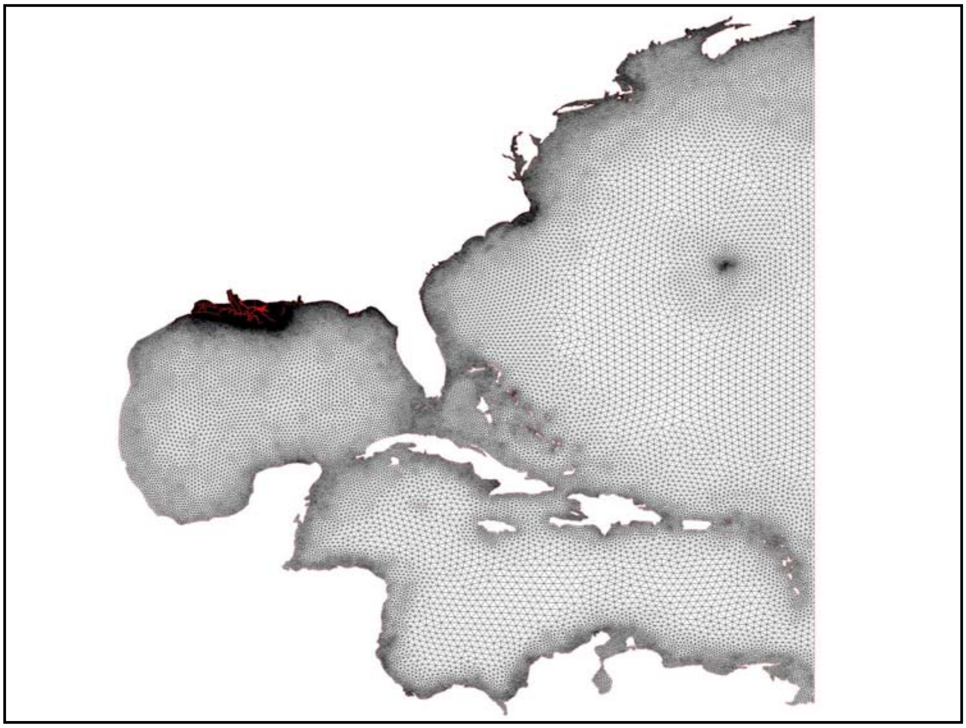
- We must sufficiently resolve the grid in order to accurately represent all pertinent flow features
- Deep ocean flow features typically exhibit the largest scales
- Shelf flow features are typically smaller
- Estuarine, riverine and coastal flood zones exhibit scales of motion several orders of magnitude smaller than in the deep ocean
- Resolve the pertinent physics on a regional basis

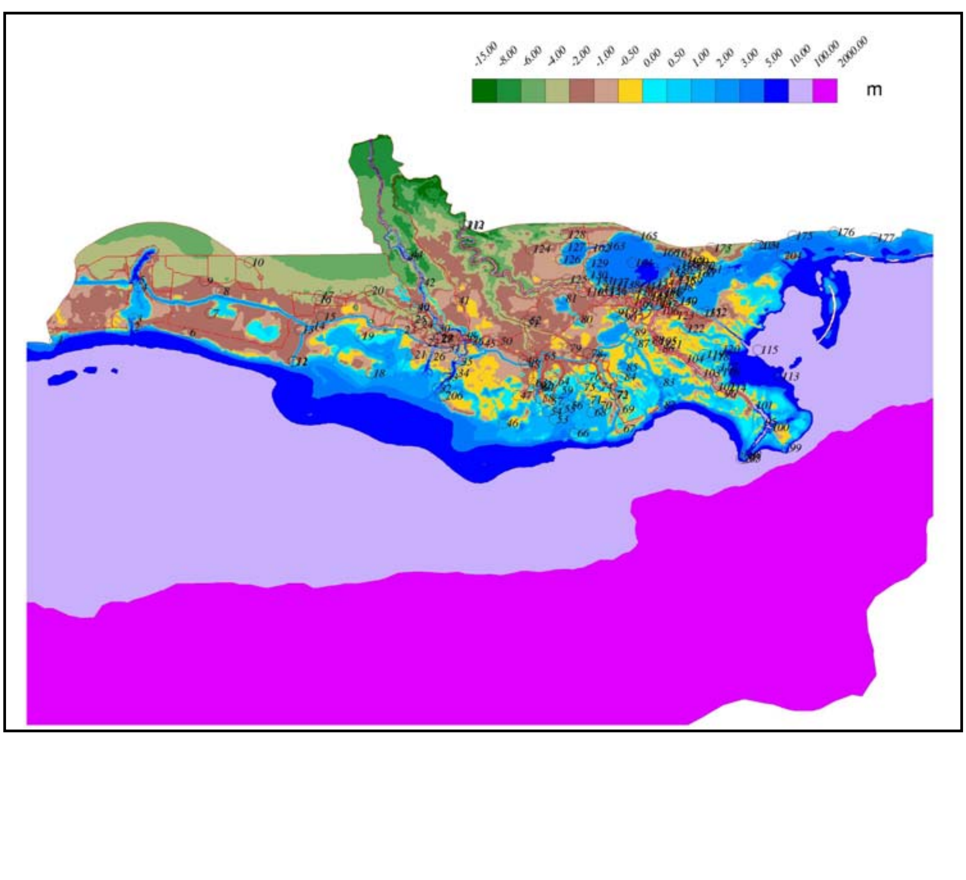
Modeling Strategy - Discretization

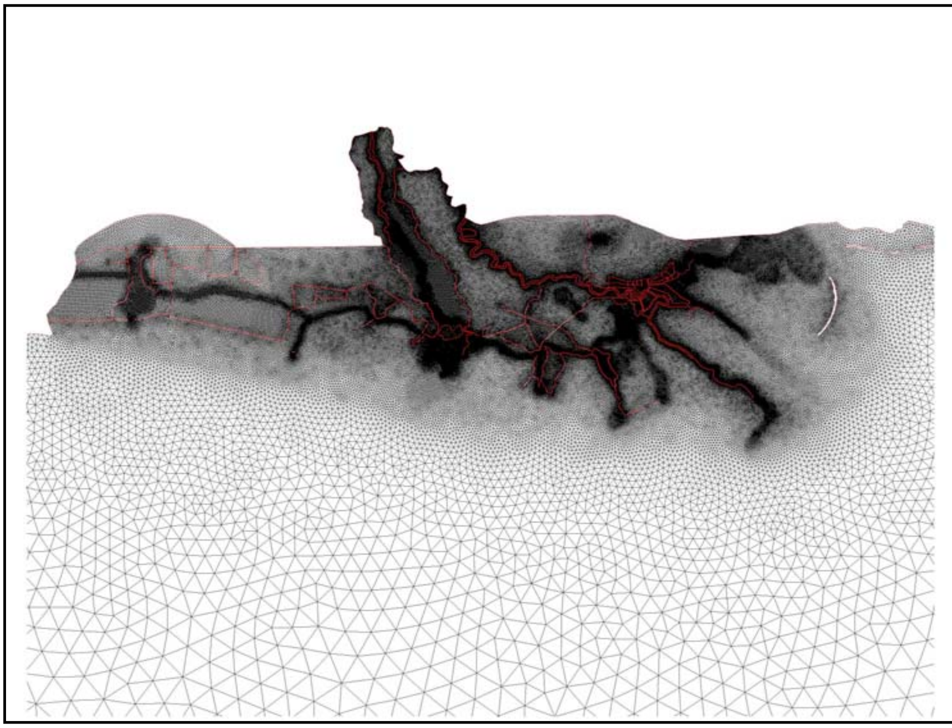
- The Finite Element method allows the construction of very flexible unstructured grids
- The Finite Element method is optimal in that the user can provide the right degree of grid resolution locally
  - Deep waters are not over-refined → computational expense is not unnecessarily driven up
  - Shallow coastal waters and complicated riverine, lake and overland regions are not under-resolved → flow features are accurately and correctly computed

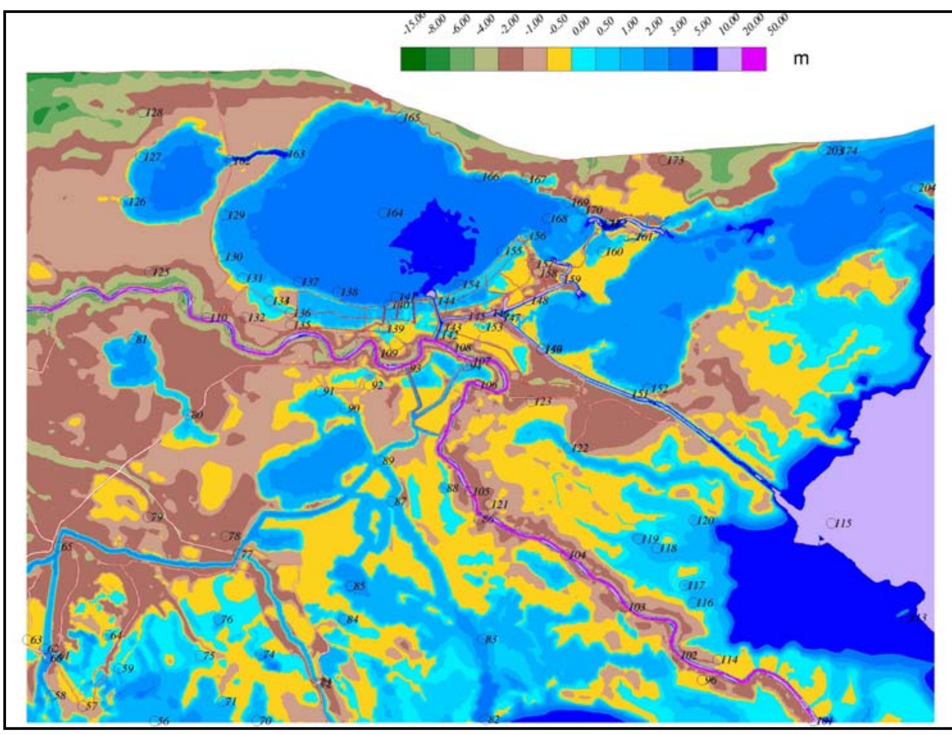
Modeling Strategy - Discretization

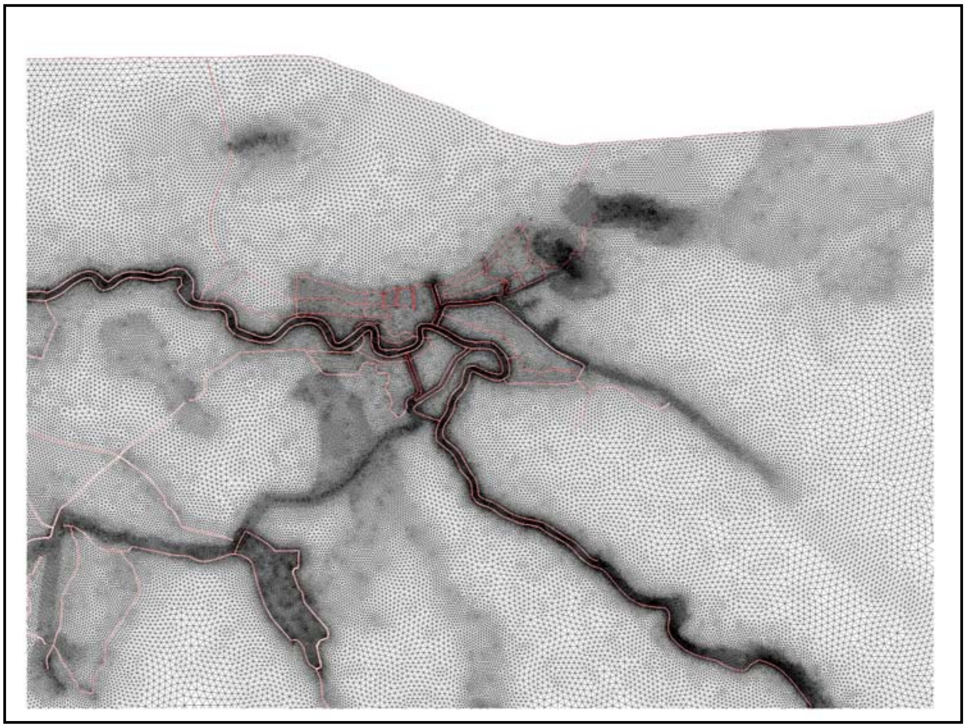
- More than 85% of the nodes in the Southern Louisiana Storm Surge grid are located within Southern Louisiana or in the adjacent coastal waters
- Computational overhead for simplifying the boundary conditions and obtaining accurate surges in southern Louisiana is only 15% of the total cost → This is very worthwhile !

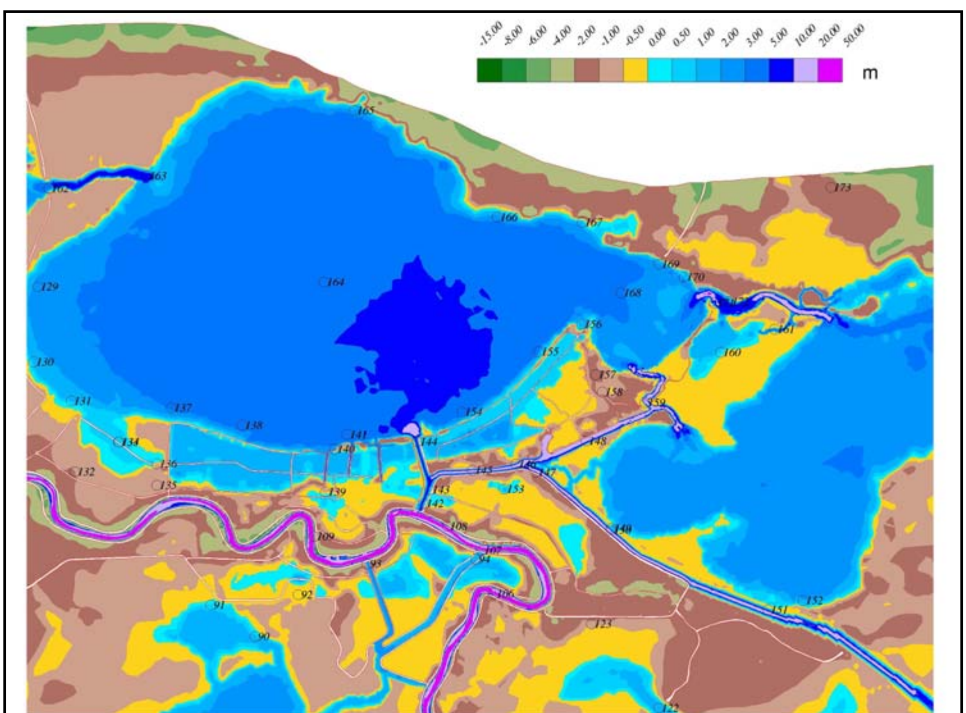


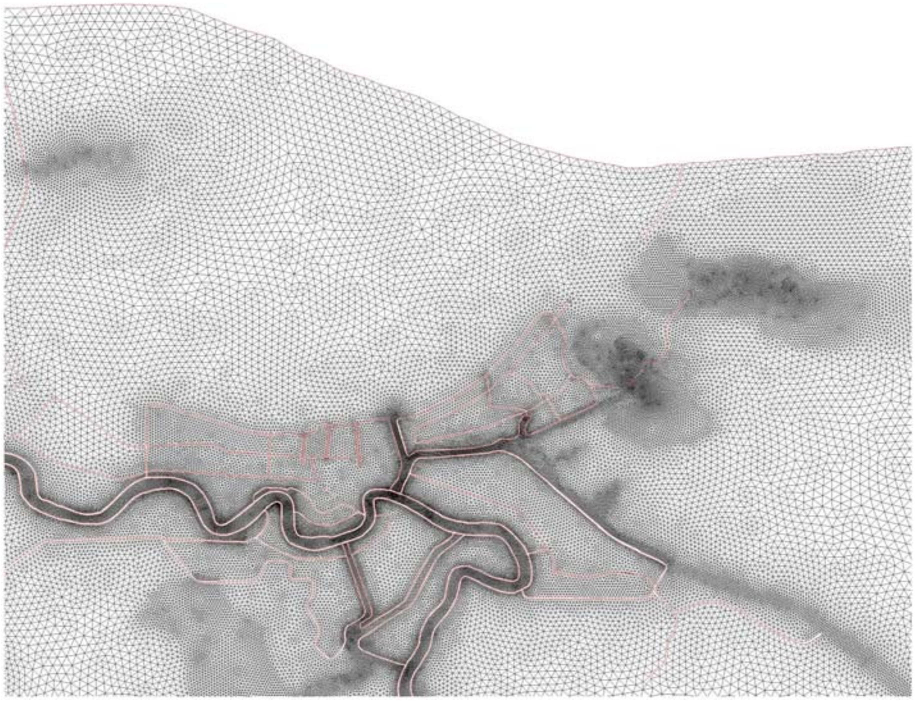

-15.00
-8.00
-6.00
-4.00
-2.00
-1.00
-0.50
0.00
0.50
1.00
2.00
3.00
5.00
10.00
100.00
2000.00
m




-15.00
-8.00
-6.00
-4.00
-2.00
-1.00
-0.50
0.00
0.50
1.00
2.00
3.00
5.00
10.00
20.00
50.00
m




-15.00 -8.00 -6.00 -4.00 -2.00 -1.00 -0.50 0.00 0.50 1.00 2.00 3.00 5.00 10.00 20.00 50.00
m



Hurricane Betsy Hindcast

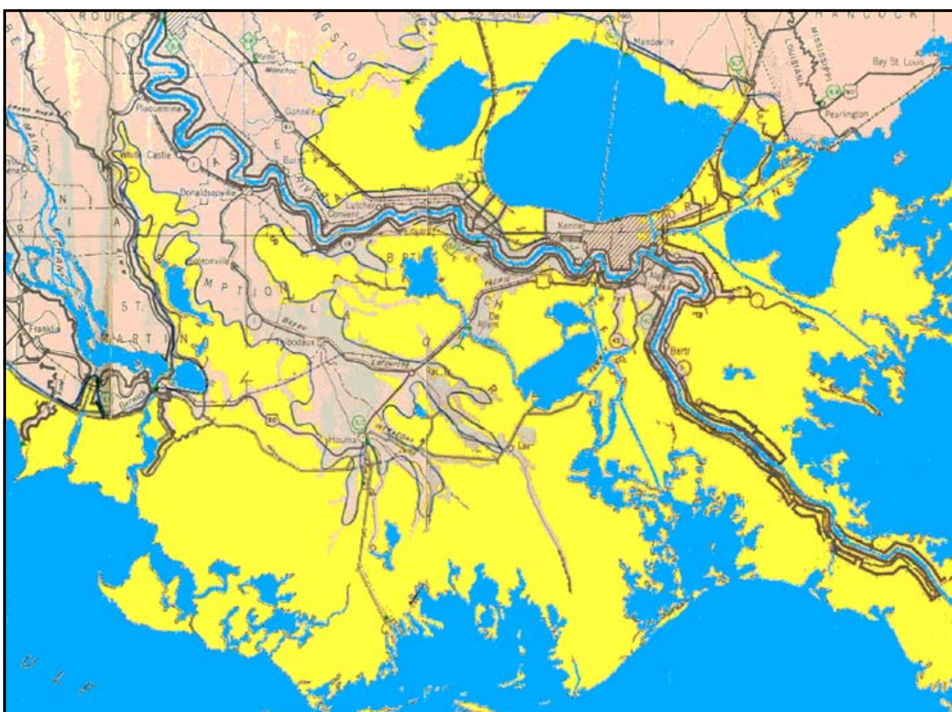
- 1965 Category 5 storm made landfall near Grand Isle, Louisiana
- Hurricane pressure and wind fields are specified as input and are generated using the Planetary Boundary Layer (PBL) model
- Levees are at 1965 heights
- Extensive flooding occurred throughout Southern Louisiana and New Orleans
- These calculations are used as model validation by comparing to tidal and river gauges
- Run on 128 processors in parallel

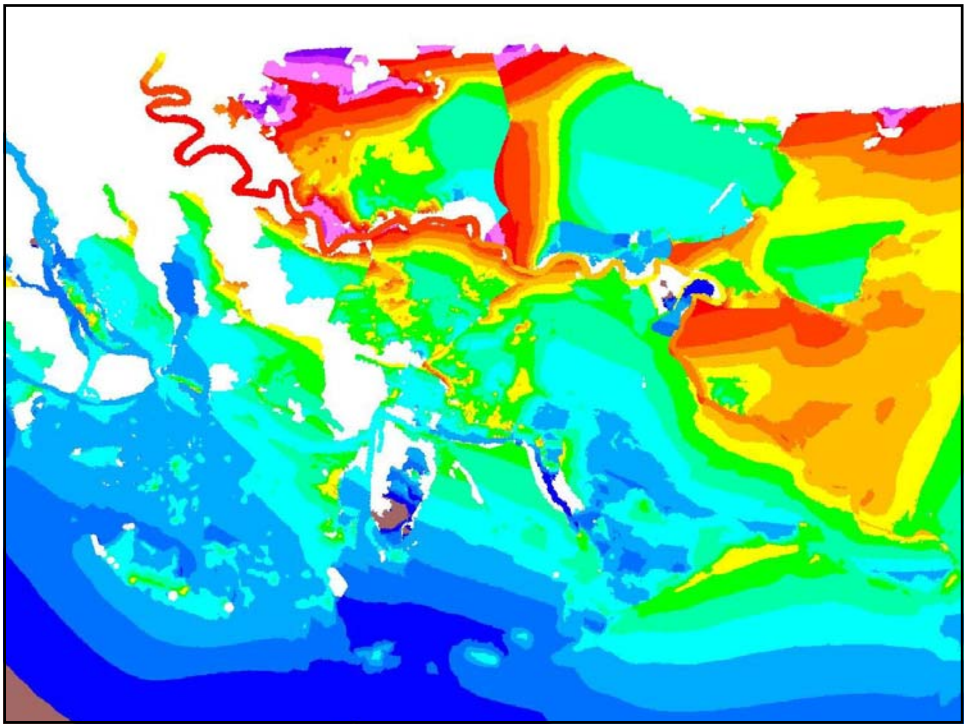

FLOOD ST.

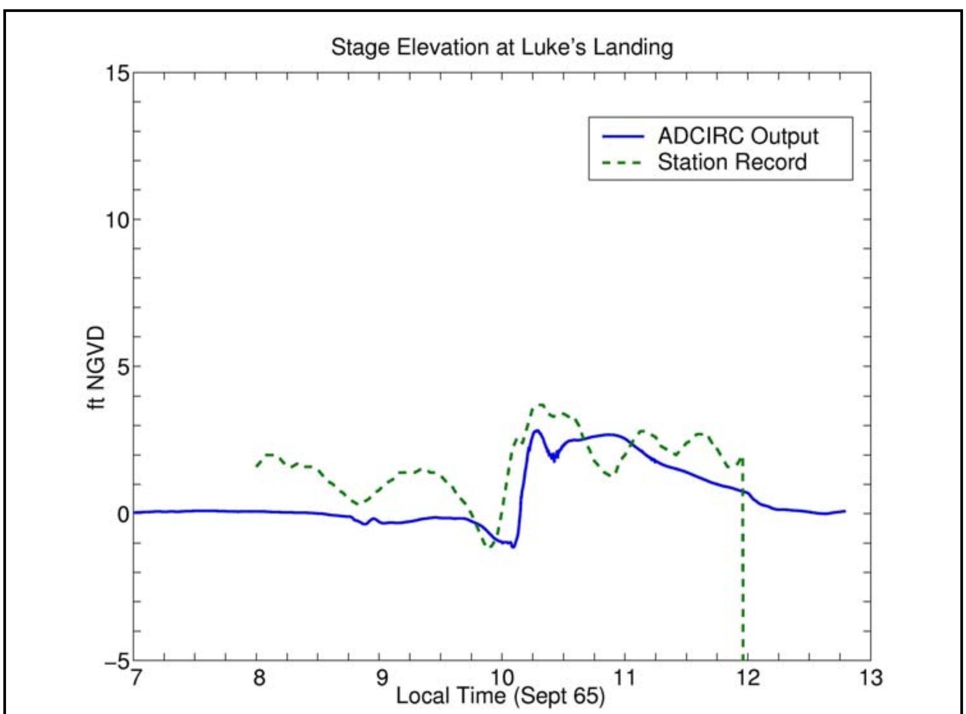

SHELL
STOP

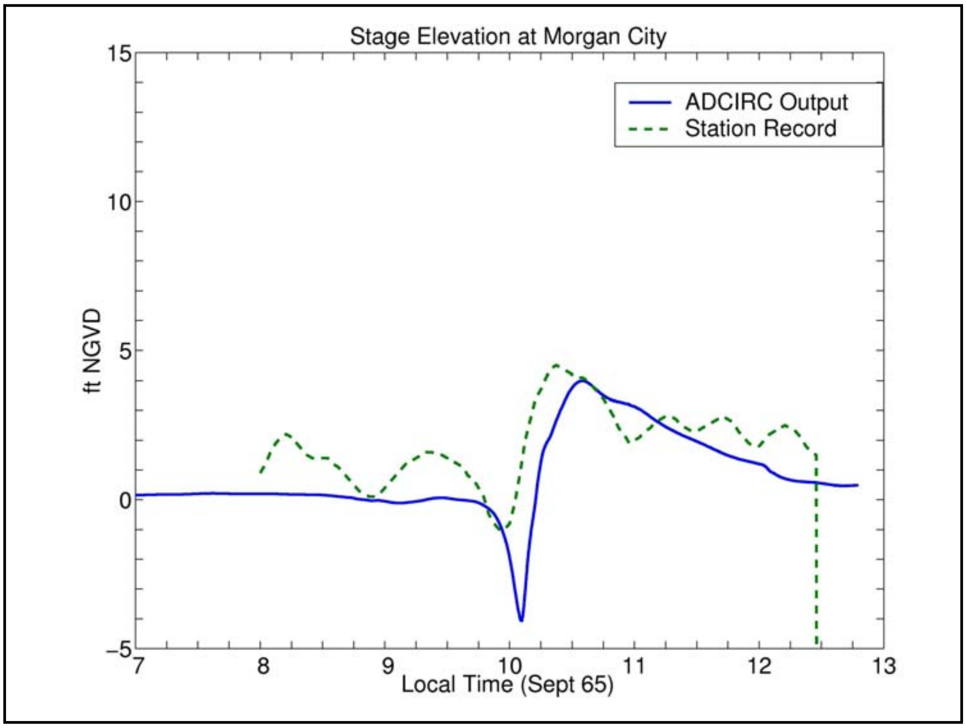
Hurricane Betsy Hindcast

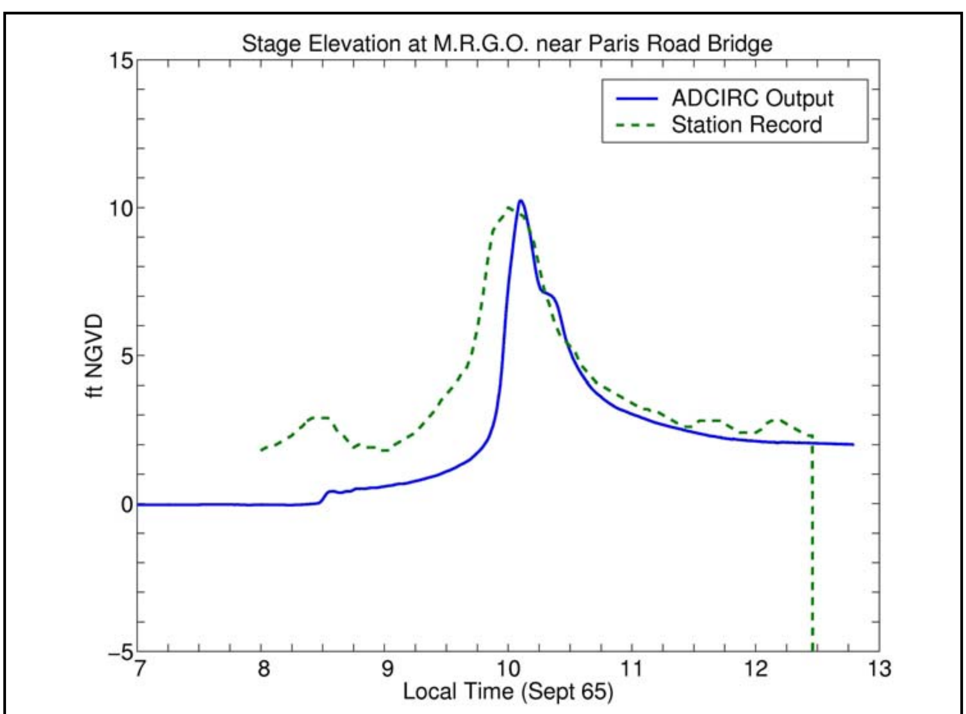
- Betsy hindcast movie

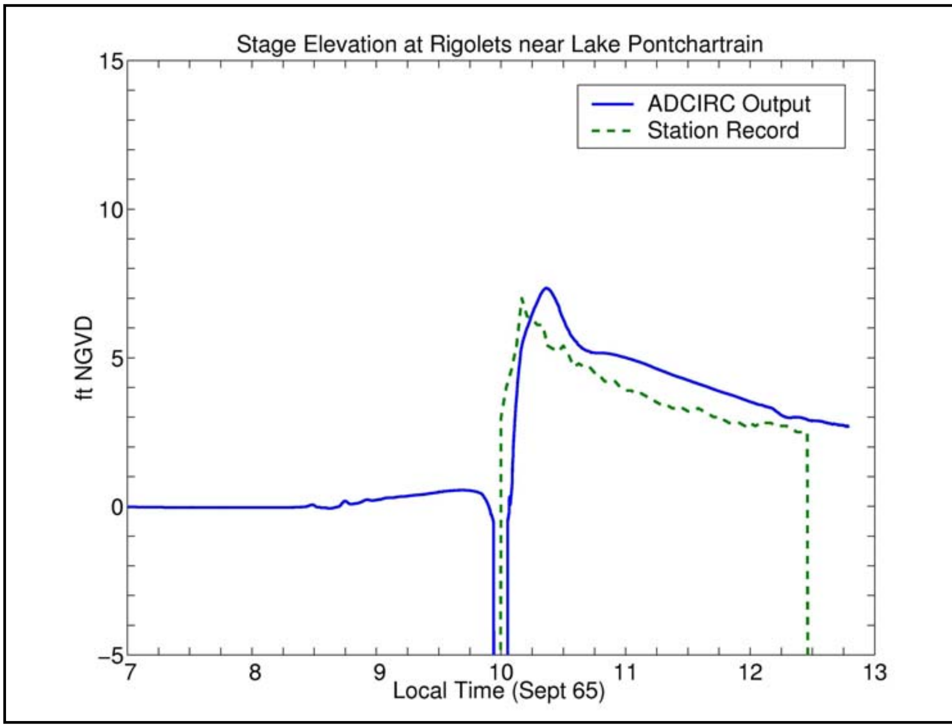


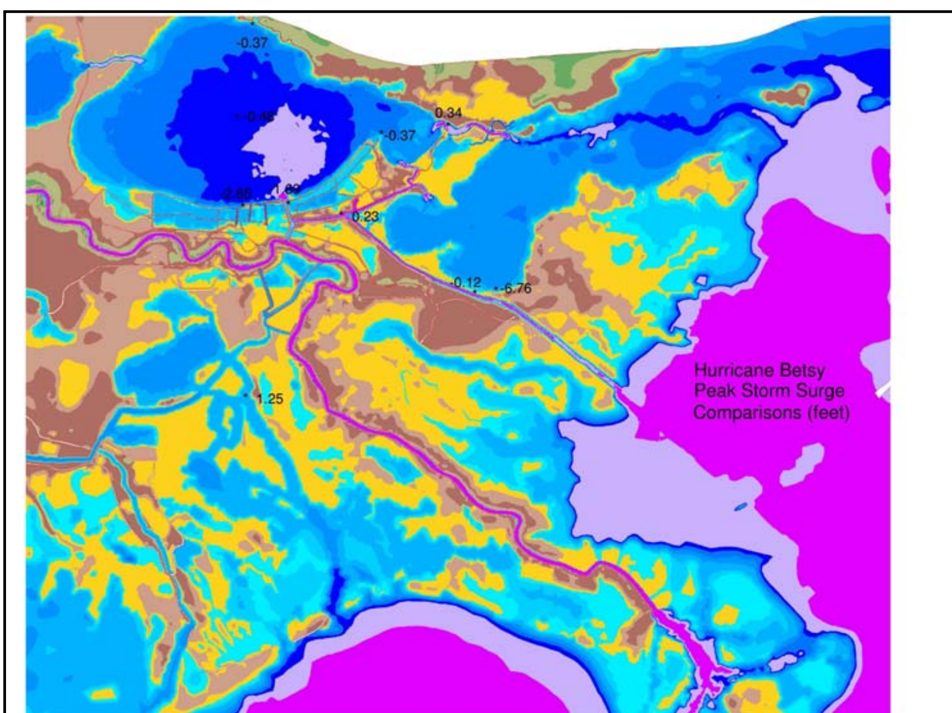



Stage Elevation at Luke's Landing
15
10
5
0
−5
ft NGVD
7
8
9
10
11
12
13
Local Time (Sept 65)
ADCIRC Output
Station Record


Stage Elevation at Morgan City
ADCIRC Output
Station Record
ft NGVD
Local Time (Sept 65)
15
10
5
0
−5
7
8
9
10
11
12
13


Stage Elevation at M.R.G.O. near Paris Road Bridge
ADCIRC Output
Station Record
ft NGVD
Local Time (Sept 65)
15
10
5
0
−5
7
8
9
10
11
12
13


Stage Elevation at Rigolets near Lake Pontchartrain
ADCIRC Output
Station Record
ft NGVD
15
10
5
0
−5
7
8
9
10
11
12
13
Local Time (Sept 65)

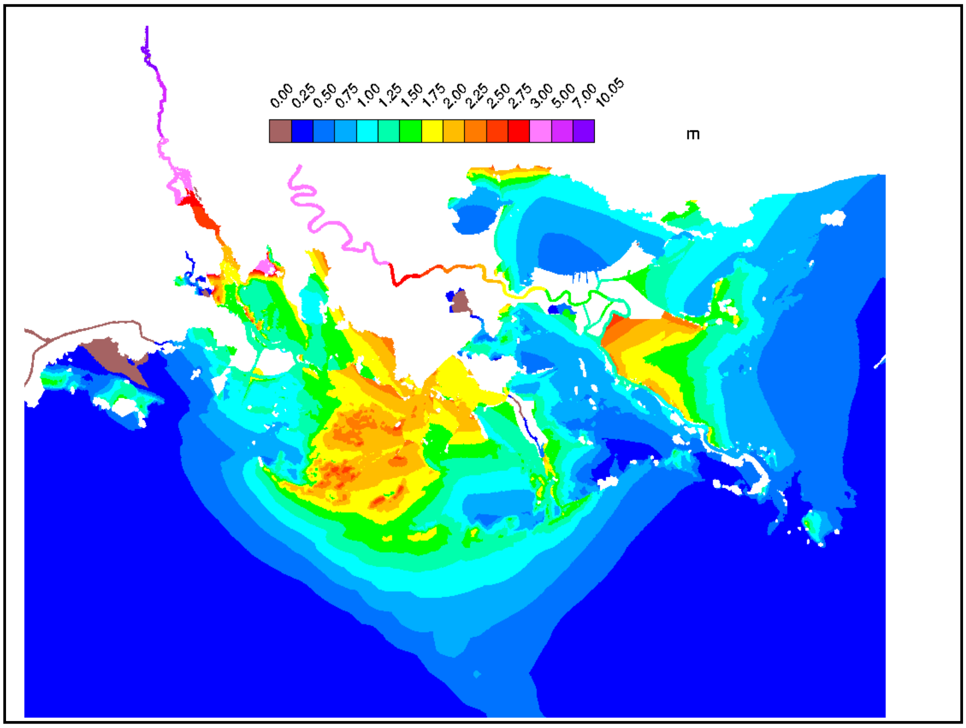

-0.37
0.34
-0.37
0.23
-0.12
-6.76
1.25
Hurricane Betsy
Peak Storm Surge
Comparisons (feet)

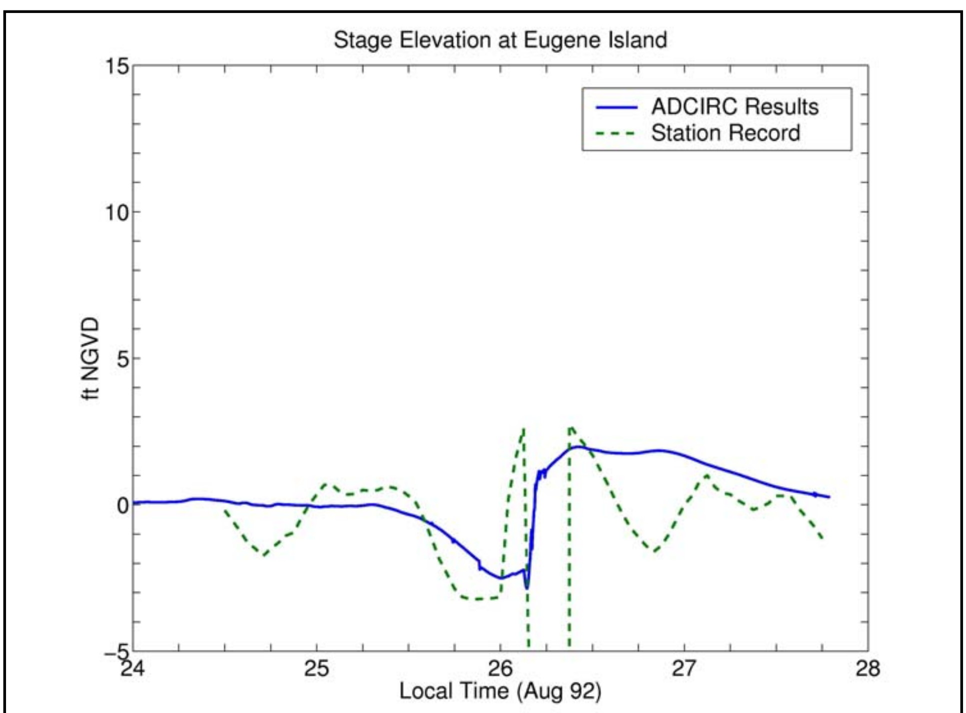
Hurricane Andrew Hindcast

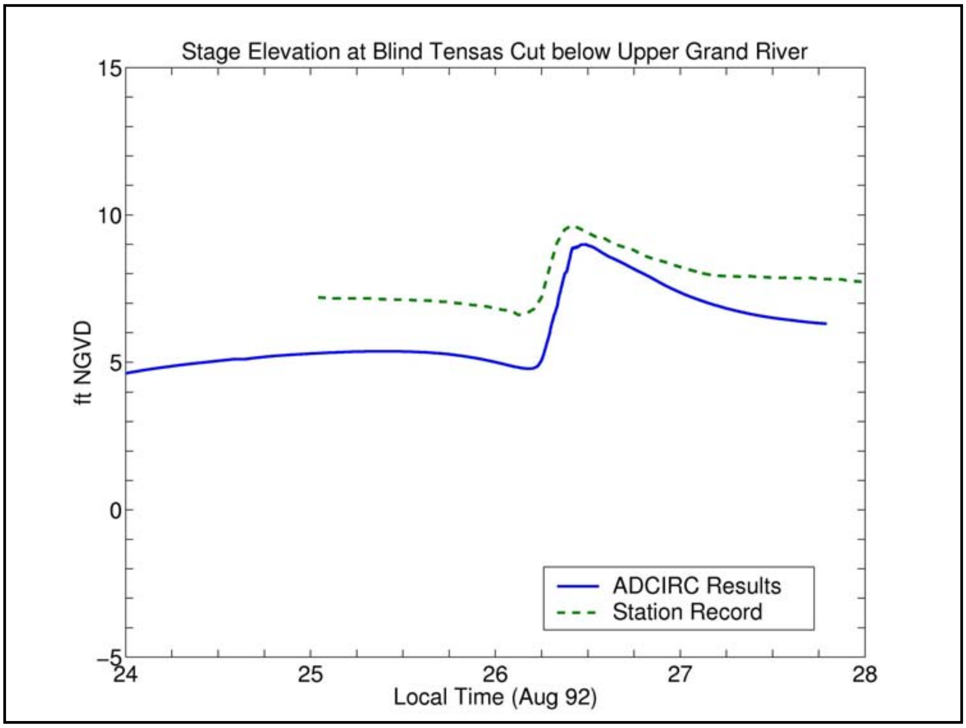
- 1992 Category 4 storm made landfall near Point Chevreuil, LA
- Hurricane pressure and wind fields were modeled by the PBL model
- Levees were included at 1992 heights
- Extensive flooding affected large areas
- Tidal and river gauging stations

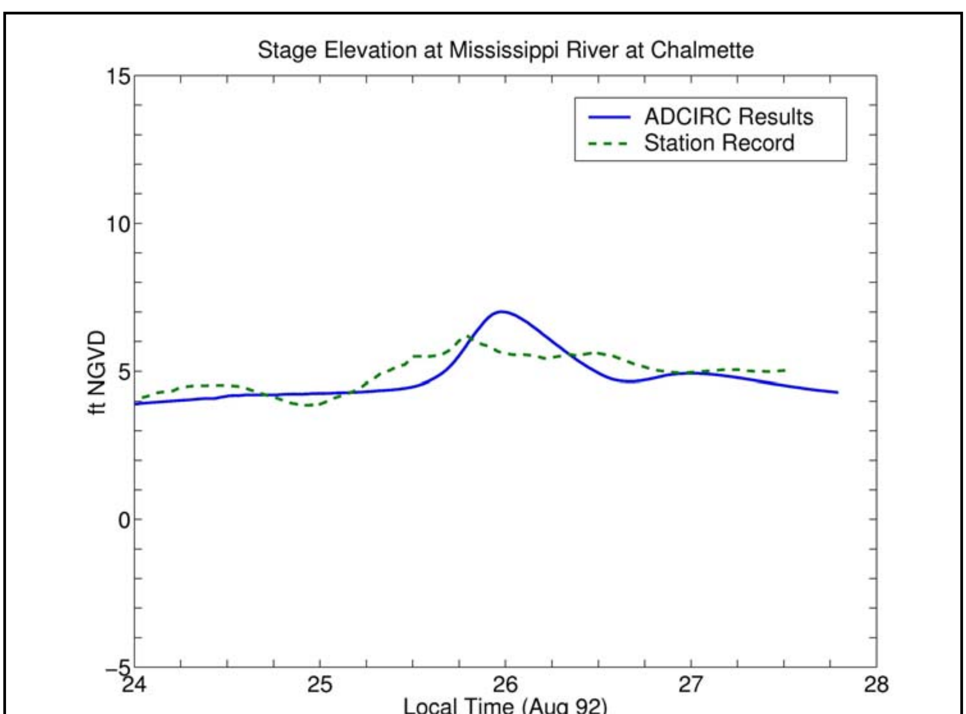
Hurricane Andrew Hindcast

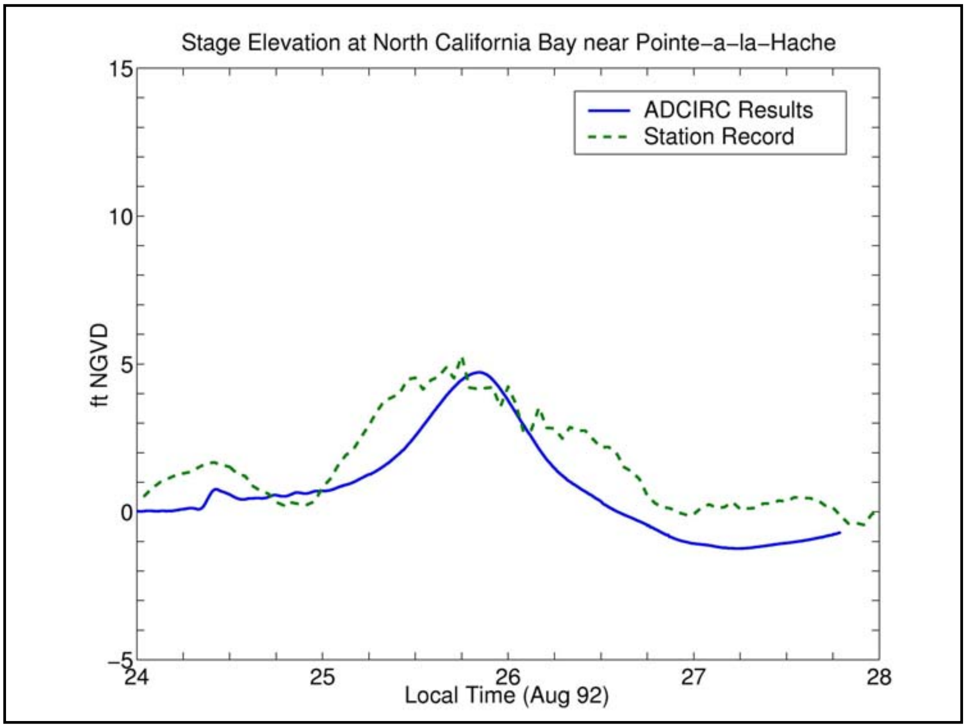
- Andrew hindcast movie

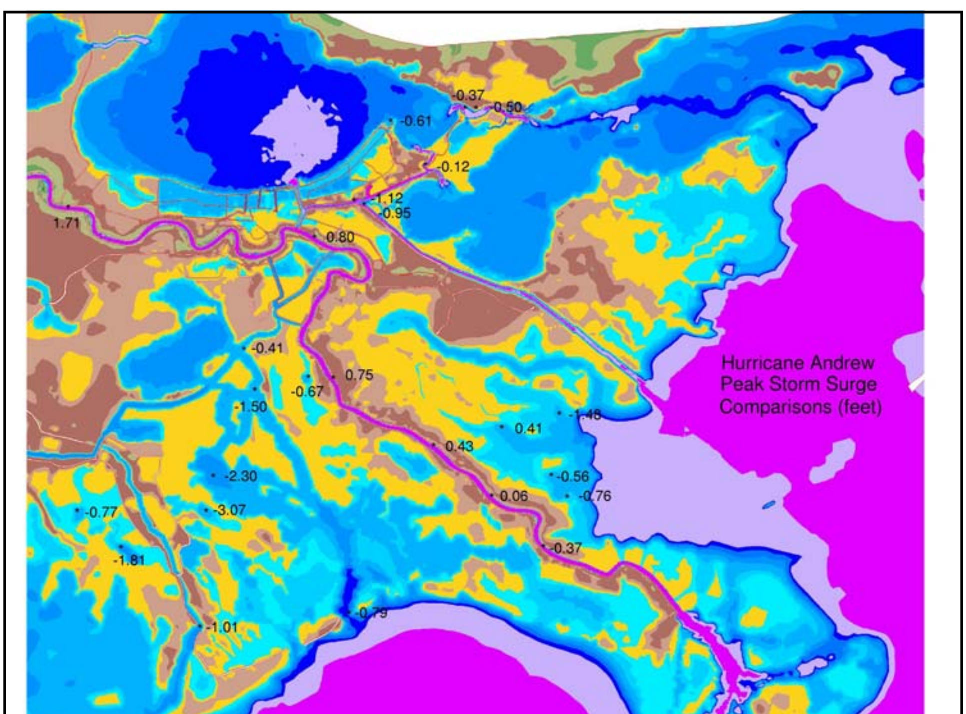

0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
5.00
7.00
10.05
m


Stage Elevation at Eugene Island
ADCIRC Results
Station Record
ft NGVD
15
10
5
0
−5
24
25
26
27
28
Local Time (Aug 92)


Stage Elevation at Blind Tensas Cut below Upper Grand River
15
10
5
0
−5
ft NGVD
24
25
26
27
28
Local Time (Aug 92)
ADCIRC Results
Station Record


Stage Elevation at Mississippi River at Chalmette
15
10
5
0
−5
ft NGVD
24
25
26
27
28
Local Time (Aug 92)
ADCIRC Results
Station Record


Stage Elevation at North California Bay near Pointe-a-la-Hache
ADCIRC Results
Station Record
ft NGVD
Local Time (Aug 92)
15
10
5
0
-5
24
25
26
27
28

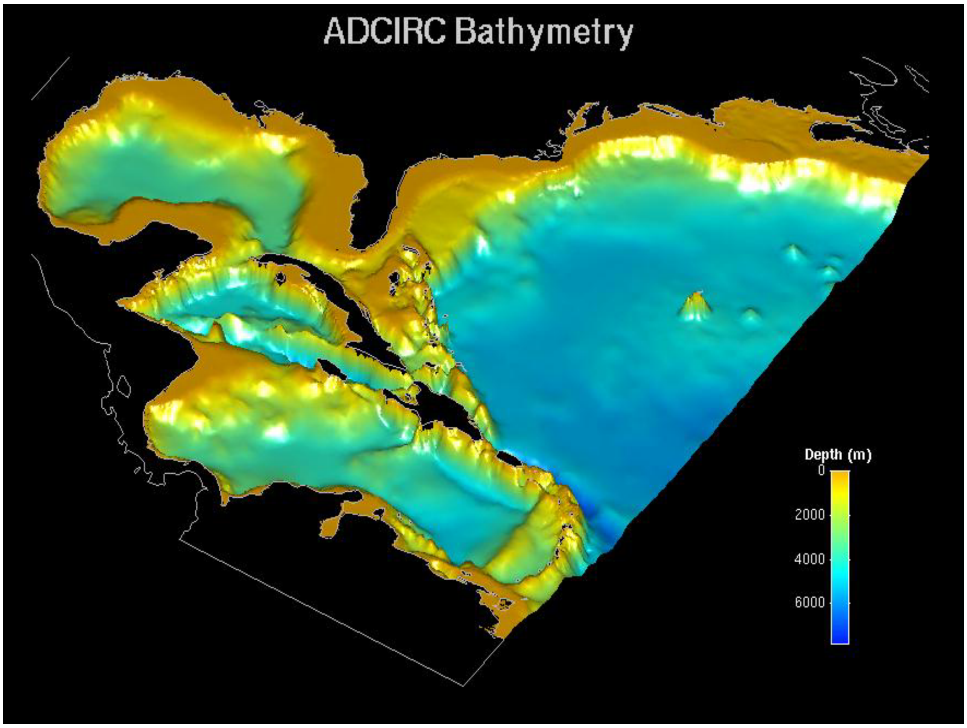

Hurricane Andrew
Peak Storm Surge
Comparisons (feet)
-0.37
0.50
-0.61
-0.12
1.12
-0.95
1.71
0.80
-0.41
0.75
-0.67
-1.50
-1.48
0.41
0.43
-2.30
-0.56
0.06
-0.76
-3.07
-0.77
-0.37
-1.81
-0.79
-1.01

Eastcoast 2001 Tidal Model

- ADCIRC application to compute tides along the U.S. East and Gulf coasts
- Hydrodynamics of coastal tides are difficult to predict because of complexities including:
  - Irregular coastlines
  - Intricacies of the ocean floor
  - Basin to basin and basin to shelf interactions
  - Interaction of astronomical and numerous non-linear tidal frequency sub-components

Eastcoast 2001 Tidal Model

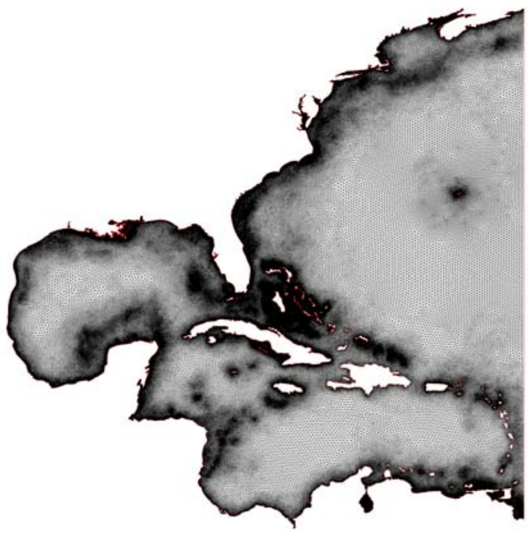
- Large domain/ localized grid refinement strategy applied in order to simplify the task of applying boundary conditions
- Domain incorporates the Western North Atlantic Ocean, Gulf of Mexico and Caribbean Sea
- Domain boundary extends to the 60 degree west meridian



Eastcoast 2001 Tidal Model

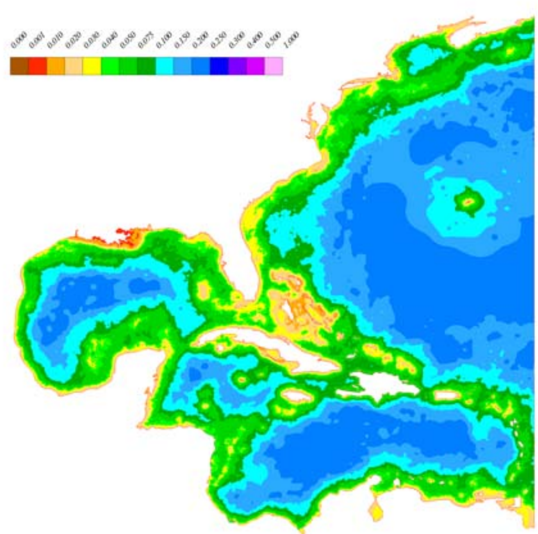
- Extensive grid development effort
  - 254,565 nodes
  - Applied linear frictionless wavelength criteria $\lambda/\Delta x = \sqrt{gh}\, T/\Delta x$ which indicates a need for increased grid resolution in shallower waters
  - Also applied Topographic Length Scale (TLS) Criterion $\Delta x \leq \alpha h/h_{,x}$ ($\alpha = \Delta x\, h_{,x} / h$) which indicates a need for increased resolution over regions with steep topographic change
  - Also applied Local Truncation Error Analysis (LTEA) estimates which indicate a need for increased resolution over regions where the response functions change rapidly

Eastcoast 2001 Grid

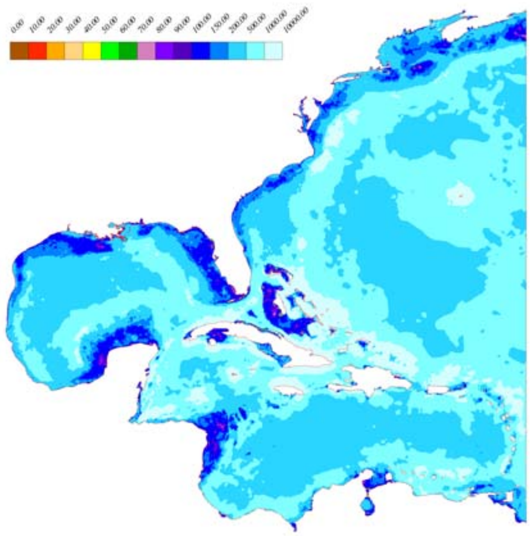


Eastcoast 2001 Grid Size in Degrees

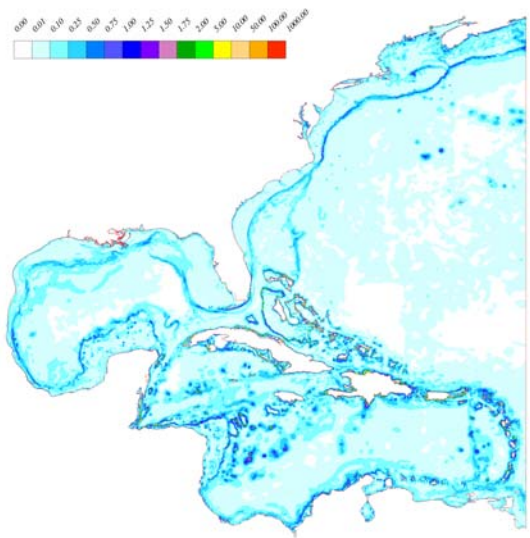
(Approximate grid size in km is obtained by multiplying legend values by 100)



***Eastcoast 2001* Wavelength to Grid Size Ratio**



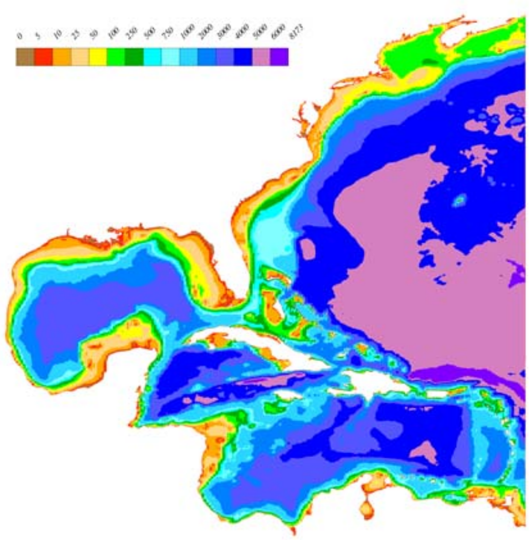
***Eastcoast 2001* Topographic Length Scale (parameter value α)**



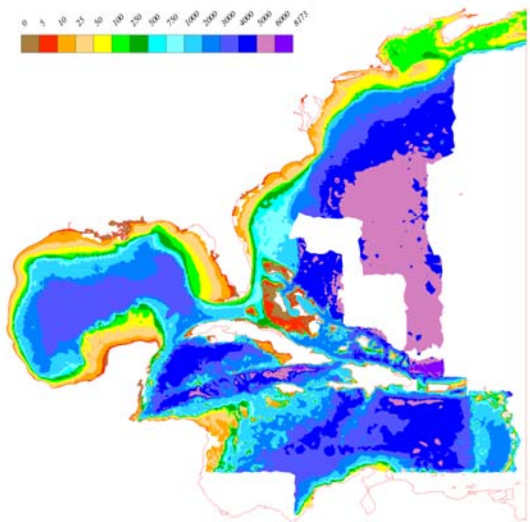
Eastcoast 2001 Tidal Model

- Significant improvements in bathymetric definitions were implemented. Composite bathymetry based on:
  - ETOPO5 Database -- 5-minute grided Earth Topography database used in all our previous tidal data bases. Covers the entire Earth but has significant errors near coasts and in the vicinity of the Bahamas.
  - DNC Database -- Digital Nautical Charts from National Imagery and Mapping Agency is accurate and offers extensive coverage
  - NOS Database -- National Ocean Service raw sounding data base with excellent coverage and accuracy along U.S. shorelines. This data was filtered onto the grid to grid scale.

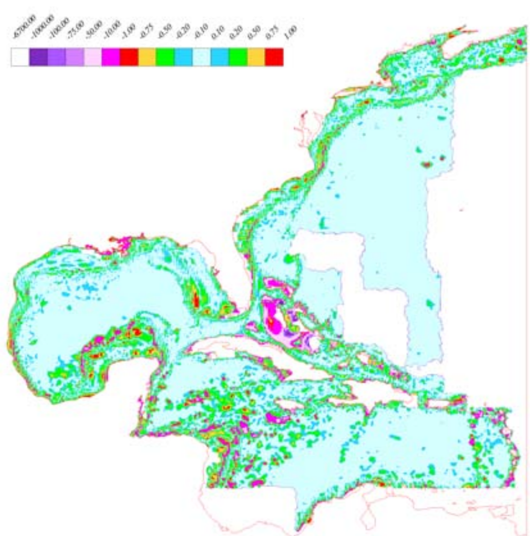
ETOPO5 Bathymetric Database
(depths in meters relative to the geoid)



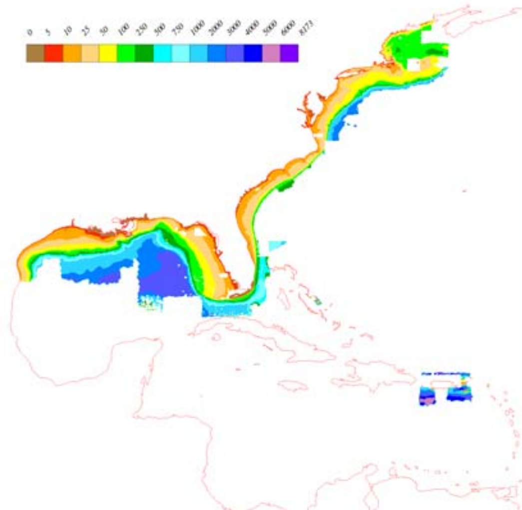
DNC Bathymetric Database
(depths in meters relative to the geoid)



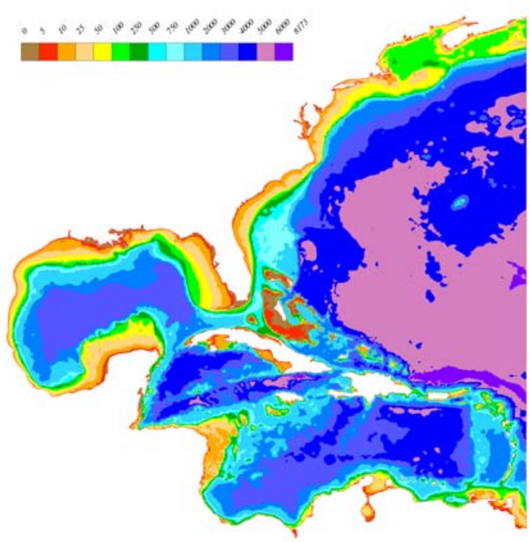
Fractional Differences between DNC and ETOPO5 Bathymetric Databases (multiply legend values by 100 to obtain percentages)



NOS Bathymetric Database
(depths in meters relative to the geoid)



Eastcoast 2001 **Composite Bathymetry**
(depths in meters relative to the geoid)



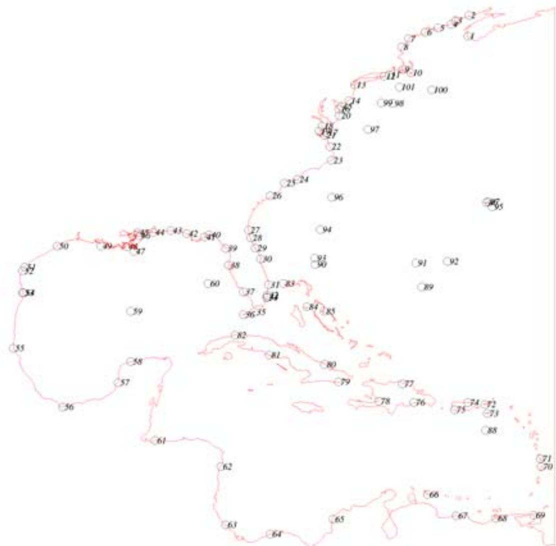
Eastcoast 2001 Tidal Model

- Open ocean boundary is forced with 7 tidal constituents
  - O1, K1, Q1, M2, N2, S2, K2 constituents are forced
  - LeProvost's global ocean FES95.2 model which includes assimilated satellite altimeter-derived data set is interpolated/extrapolated onto the ADCIRC grid 60 degree west boundary
- Forcing also includes tidal potential forcing for the same 7 constituents

Eastcoast 2001 Tidal Model

- Results are validated by comparing computed constituent amplitude and phase to measured tidal constituent data at 101 stations distributed throughout the domain.
- Error estimates of the measurement data were also made
- Comparisons are also made to 2 previous ADCIRC tidal data bases in order to assess the level of improvement
  - *Eastcoast 1991* which used 19,858 nodes
  - *Eastcoast 1995* which used 31,435 nodes
- Significant level of improvement compared to previous computations due to:
  - Improved resolution (global and distribution!!)
  - Improved bathymetry

101 Elevation Measurement Stations



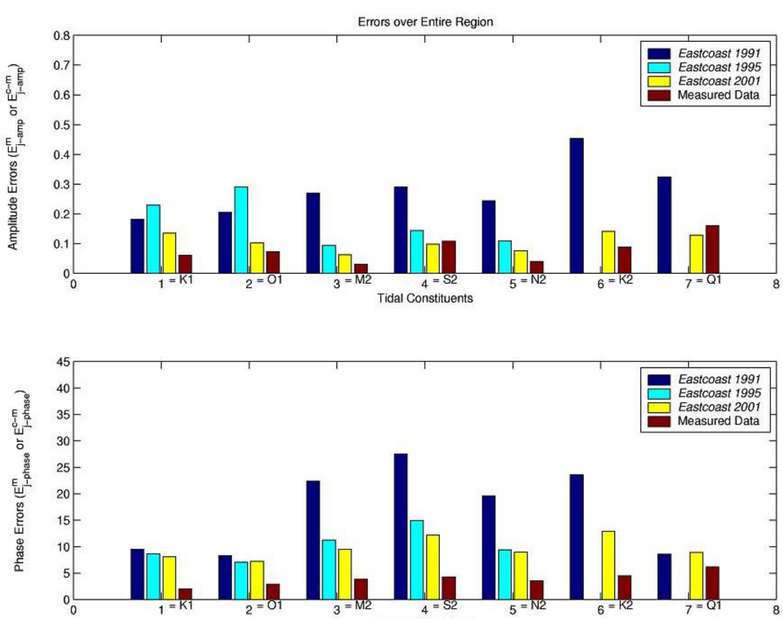
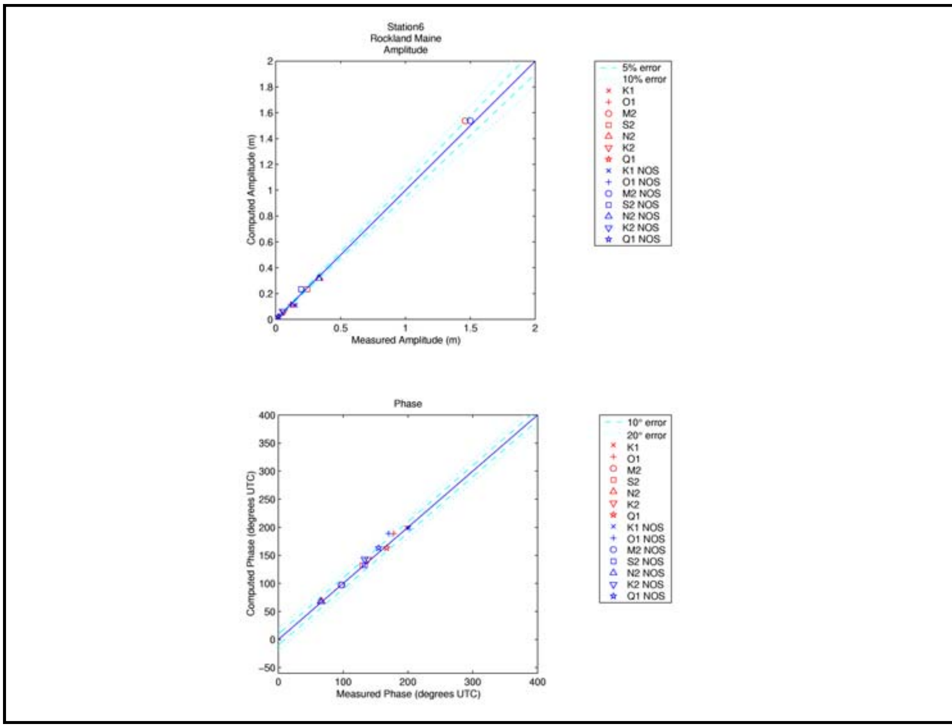
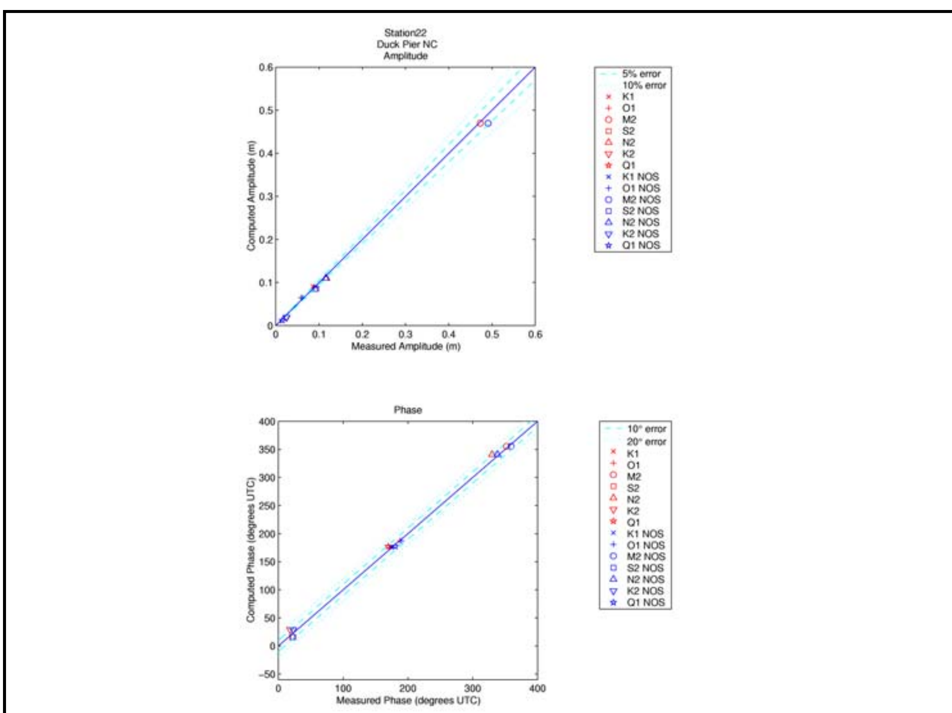


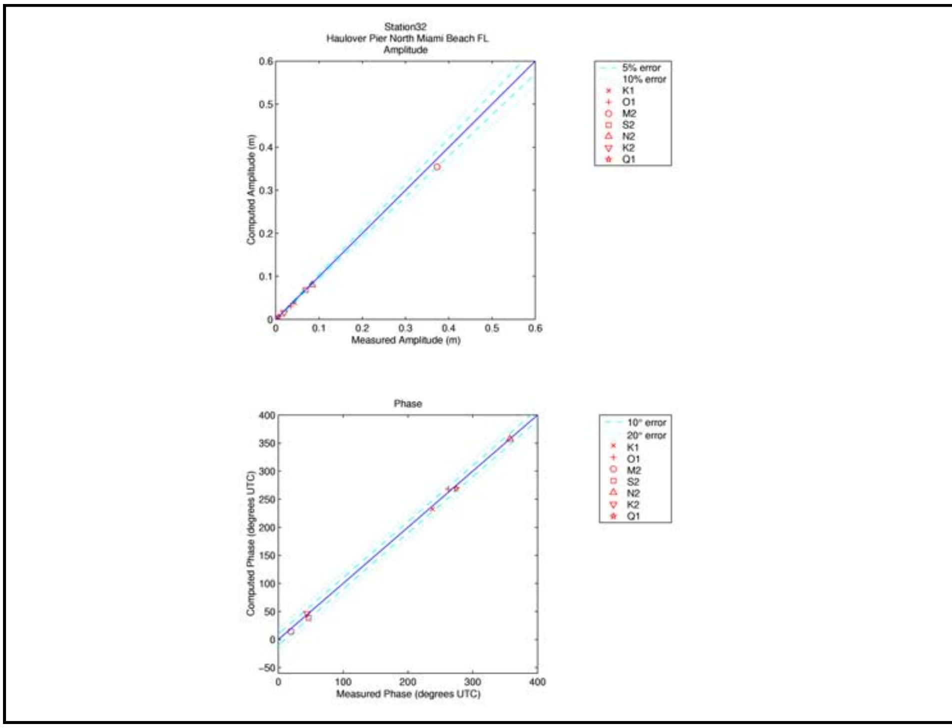
FIGURE 147. Harmonic Constituent Error Comparison between Databases over the Entire Domain

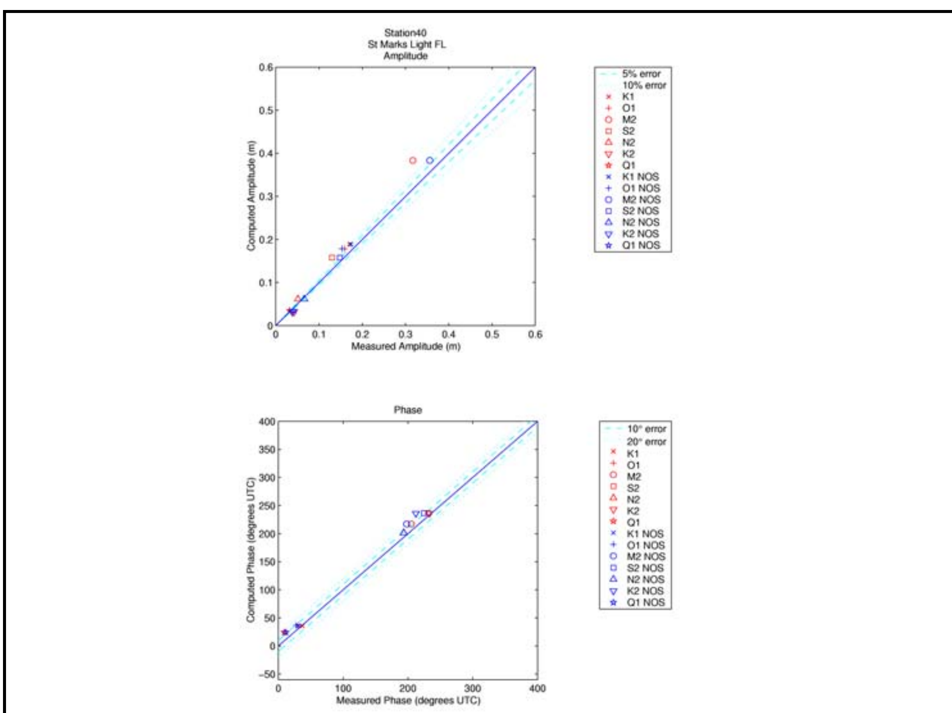


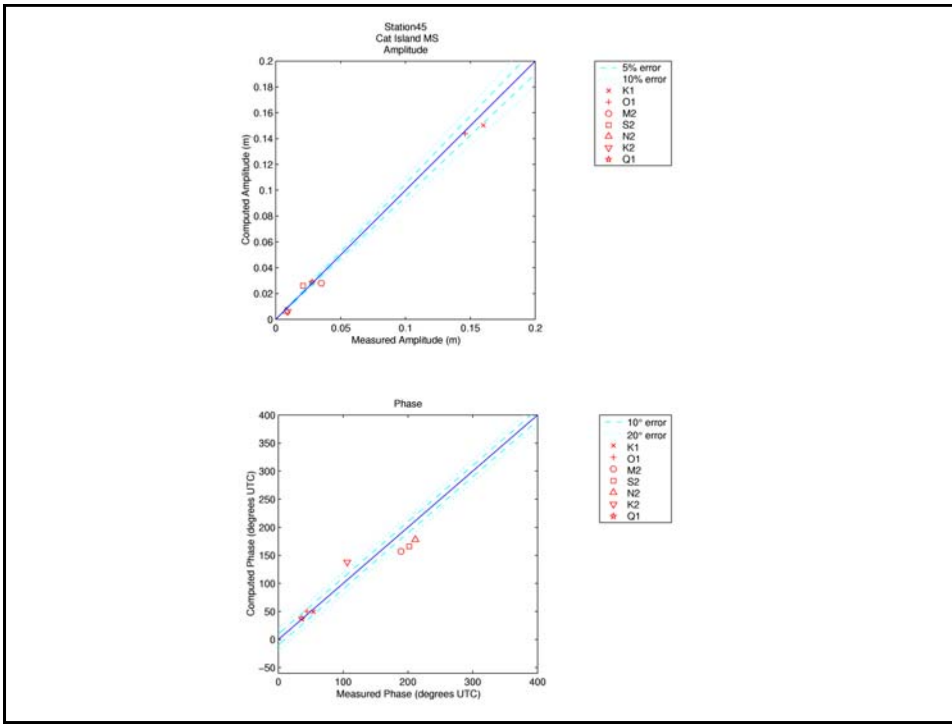
Station6
Rockland Maine
Amplitude
Computed Amplitude (m)
Measured Amplitude (m)
5% error
10% error
K1
O1
M2
S2
N2
K2
Q1
K1 NOS
O1 NOS
M2 NOS
S2 NOS
N2 NOS
K2 NOS
Q1 NOS
Phase
Computed Phase (degrees UTC)
Measured Phase (degrees UTC)
10° error
20° error

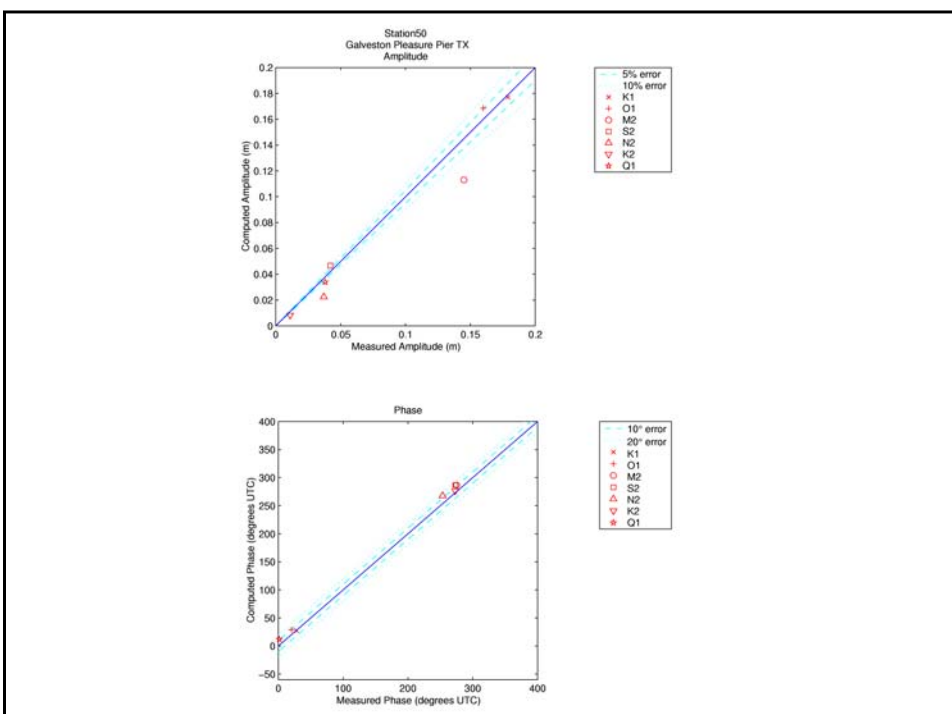


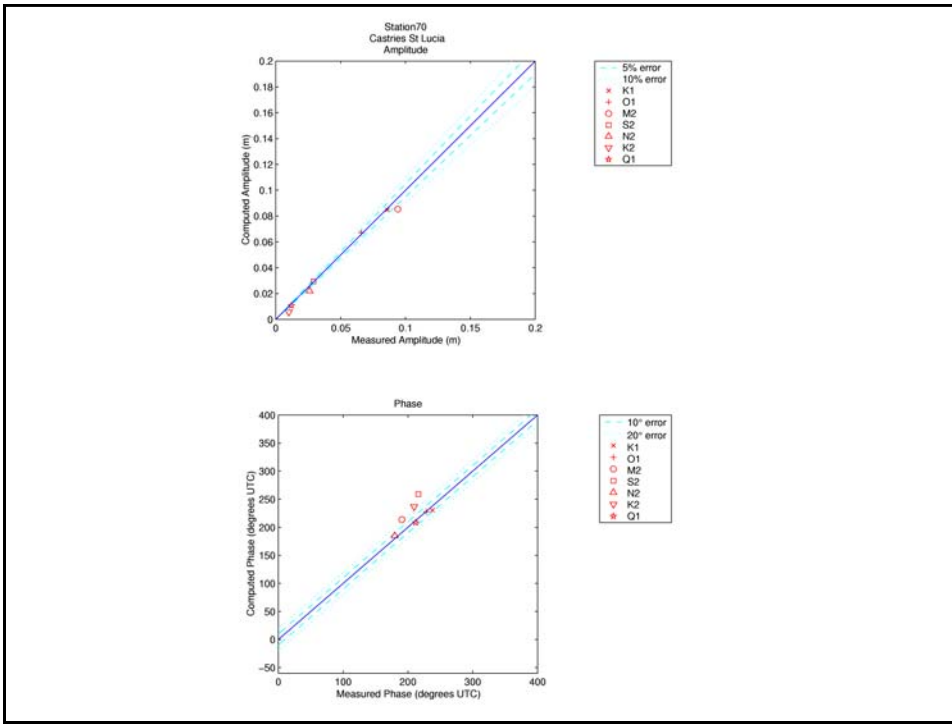
Station22
Duck Pier NC
Amplitude
Computed Amplitude (m)
Measured Amplitude (m)
5% error
10% error
K1
O1
M2
S2
N2
K2
Q1
K1 NOS
O1 NOS
M2 NOS
S2 NOS
N2 NOS
K2 NOS
Q1 NOS
Phase
Computed Phase (degrees UTC)
Measured Phase (degrees UTC)
10° error
20° error

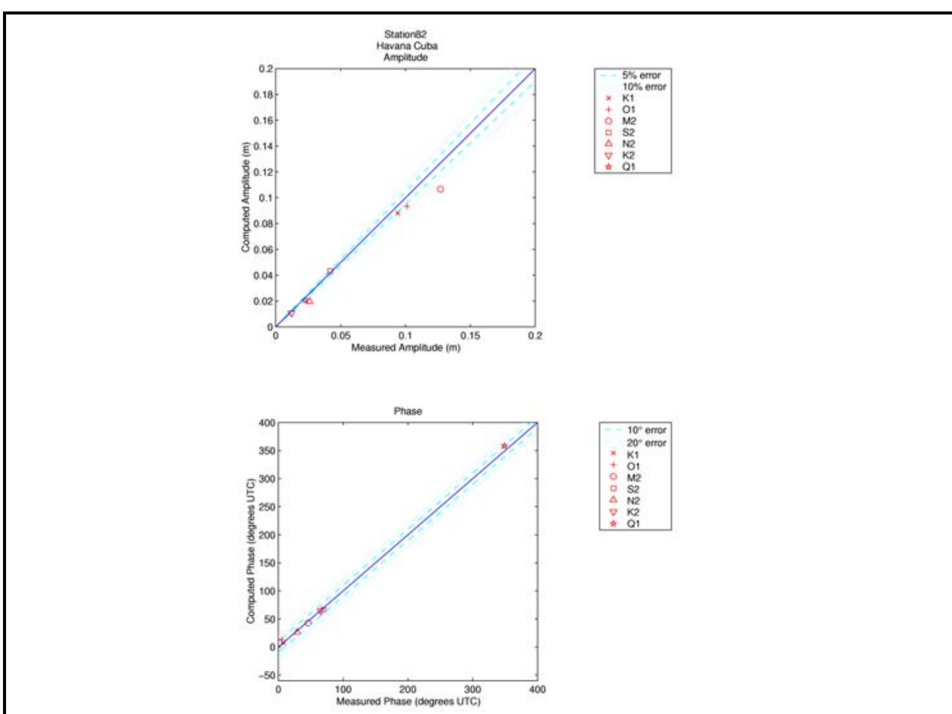

Station32
Haulover Pier North Miami Beach FL
Amplitude
Computed Amplitude (m)
Measured Amplitude (m)
5% error
10% error
K1
O1
M2
S2
N2
K2
Q1
Phase
Computed Phase (degrees UTC)
Measured Phase (degrees UTC)
10° error
20° error

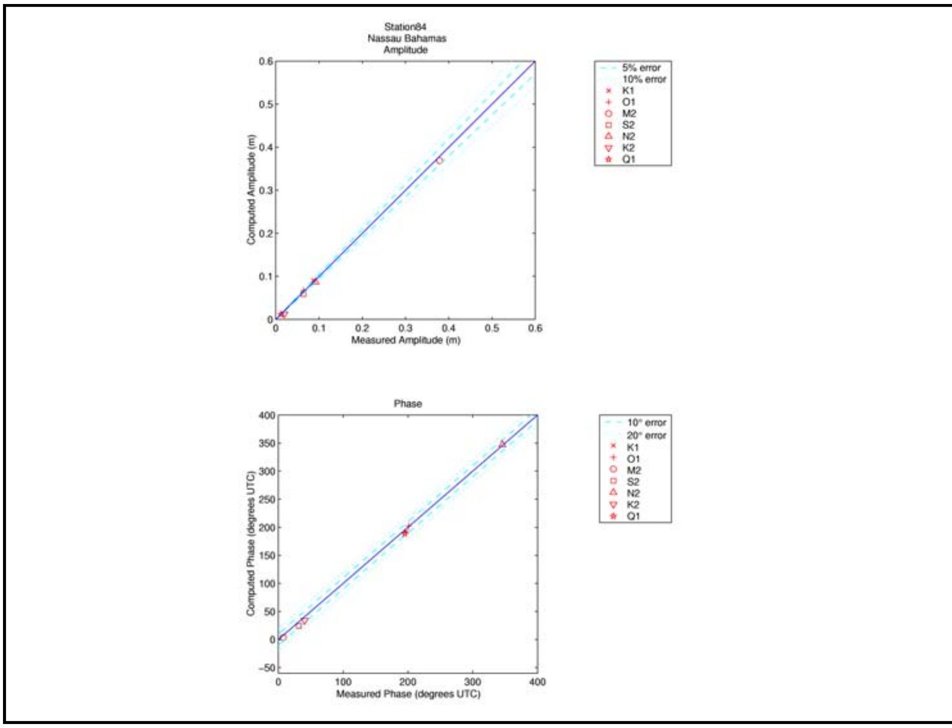

Station40
St Marks Light FL
Amplitude
Computed Amplitude (m)
Measured Amplitude (m)
5% error
10% error
K1
O1
M2
S2
N2
K2
Q1
K1 NOS
O1 NOS
M2 NOS
S2 NOS
N2 NOS
K2 NOS
Q1 NOS
Phase
Computed Phase (degrees UTC)
Measured Phase (degrees UTC)
10° error
20° error

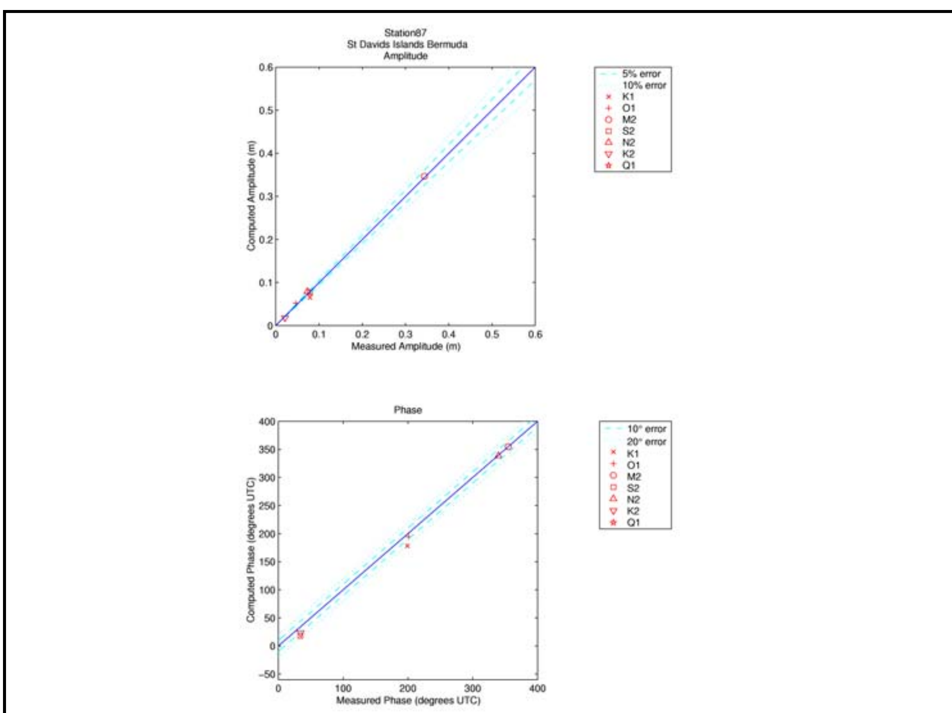

Station45
Cat Island MS
Amplitude
5% error
10% error
K1
O1
M2
S2
N2
K2
Q1
Computed Amplitude (m)
Measured Amplitude (m)
Phase
10° error
20° error
Computed Phase (degrees UTC)
Measured Phase (degrees UTC)

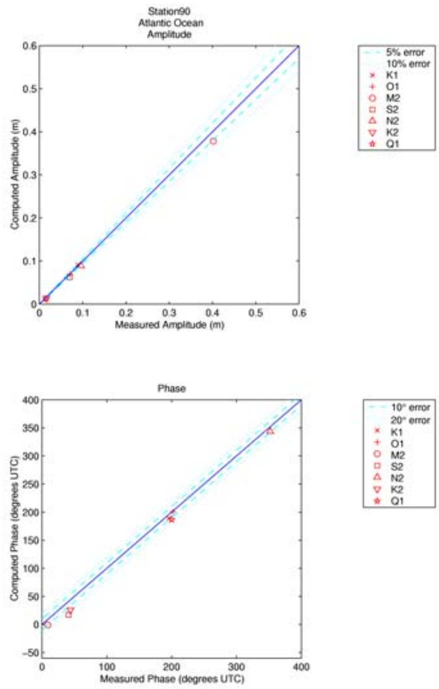

Station50
Galveston Pleasure Pier TX
Amplitude
5% error
10% error
K1
O1
M2
S2
N2
K2
Q1
Computed Amplitude (m)
Measured Amplitude (m)
Phase
10° error
20° error
Computed Phase (degrees UTC)
Measured Phase (degrees UTC)


Station70
Castries St Lucia
Amplitude
Computed Amplitude (m)
Measured Amplitude (m)
5% error
10% error
K1
O1
M2
S2
N2
K2
Q1
Phase
Computed Phase (degrees UTC)
Measured Phase (degrees UTC)
10° error
20° error
K1
O1
M2
S2
N2
K2
Q1


Station82
Havana Cuba
Amplitude
Computed Amplitude (m)
Measured Amplitude (m)
5% error
10% error
K1
O1
M2
S2
N2
K2
Q1
Phase
Computed Phase (degrees UTC)
Measured Phase (degrees UTC)
10° error
20° error
K1
O1
M2
S2
N2
K2
Q1


Station84
Nassau Bahamas
Amplitude
Computed Amplitude (m)
Measured Amplitude (m)
5% error
10% error
K1
O1
M2
S2
N2
K2
Q1
Phase
Computed Phase (degrees UTC)
Measured Phase (degrees UTC)
10° error
20° error


Station87
St Davids Islands Bermuda
Amplitude
Computed Amplitude (m)
Measured Amplitude (m)
5% error
10% error
K1
O1
M2
S2
N2
K2
Q1
Phase
Computed Phase (degrees UTC)
Measured Phase (degrees UTC)
10° error
20° error



Eastcoast 2001 Tidal Model

- *Eastcoast 2001* represents the most accurate tidal constituent data base for the Western North Atlantic Ocean and Gulf of Mexico
- *Eastcoast 2001* Tidal Constituent Data Base
  - Allows extraction of 7 constituent data at any point in the WNAT domain
  - Available through ADCIRC Web site, WES, SMS
  - Thoroughly documented through TR and CHETN
- Used for
  - Navigation and engineering studies
  - Providing *physically balanced* boundary conditions for localized estuarine and inlet models

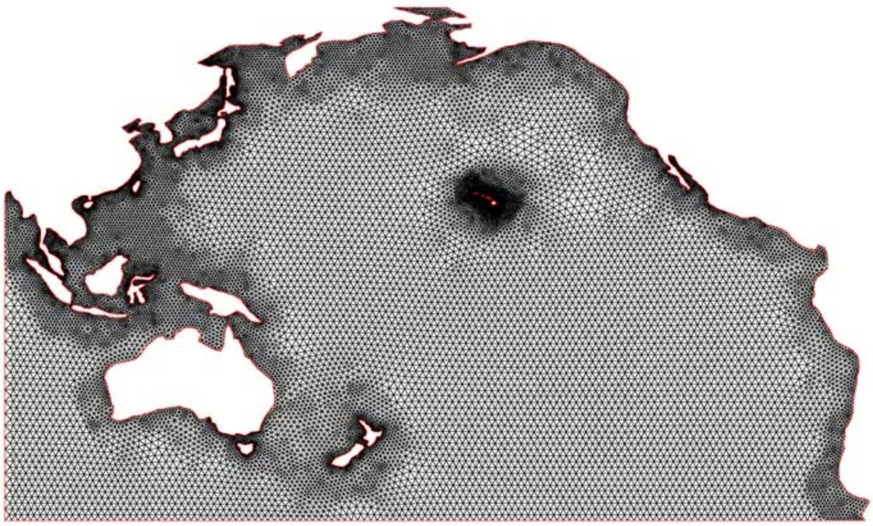
Eastcoast 2001 Tidal Model

- Important considerations for application of the *Eastcoast 2001* results in driving smaller nested hydrodynamic models
  - Bathymetry at the nesting interface must match between the *Eastcoast 2001* grid and the smaller nested grid.
    - The *Eastcoast 2001* results are dynamically correctly balanced for the specified bathymetry. Changing this bathymetry will cause the *Eastcoast 2001* data base results to be incorrectly balanced. The nested model will try to adjust for this and will lead to very poor results.
  - No significant additional physics can be added to the nested models without possibly creating problems in the vicinity of the boundary.
    - Specialized radiation boundary conditions would have to be added in order to accommodate the added physics
  - The reduced accuracy at the boundary may be a factor in the resulting computations

ADCIRC Applications Worldwide

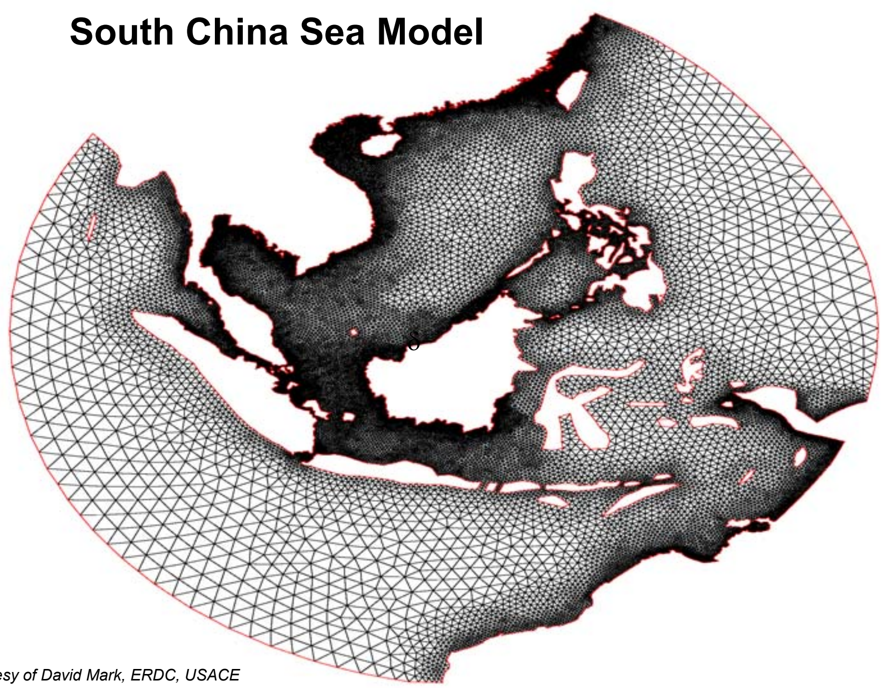
- ADCIRC is used for tidal and hurricane storm surge calculations worldwide for the U.S. Army and Navy
- Studies domains range from basin scale to inlets
- Computed hydrodynamics ranges from basin scale circulation to wind wave scale

Pacific/Hawaii Tsunami Model



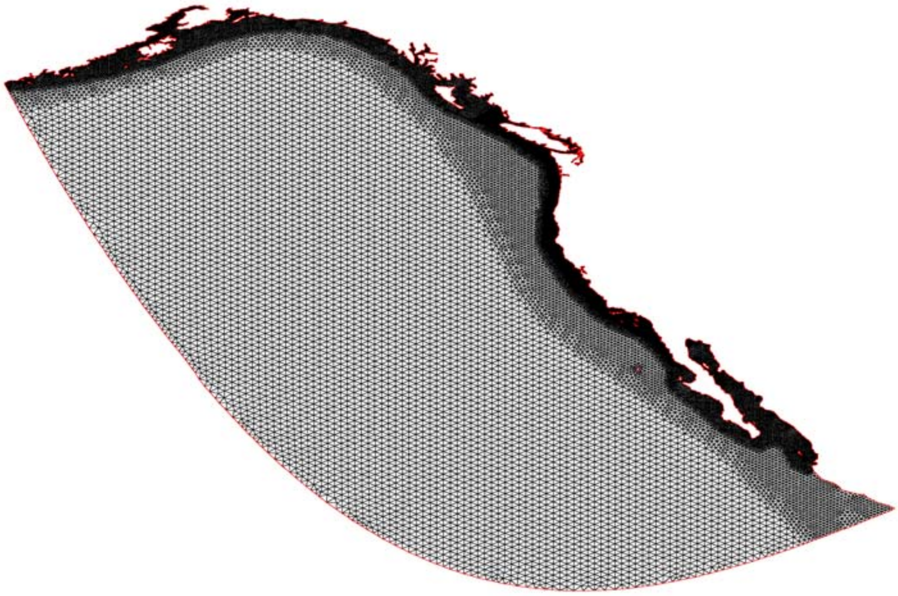
Courtesy of Norm Scheffner, ERDC, USACE

South China Sea Model

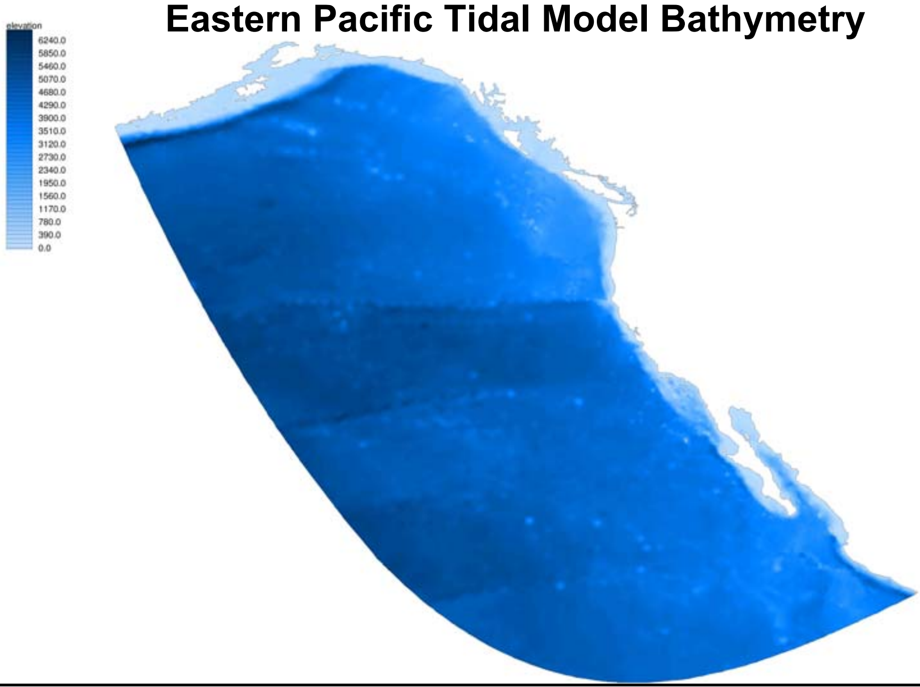


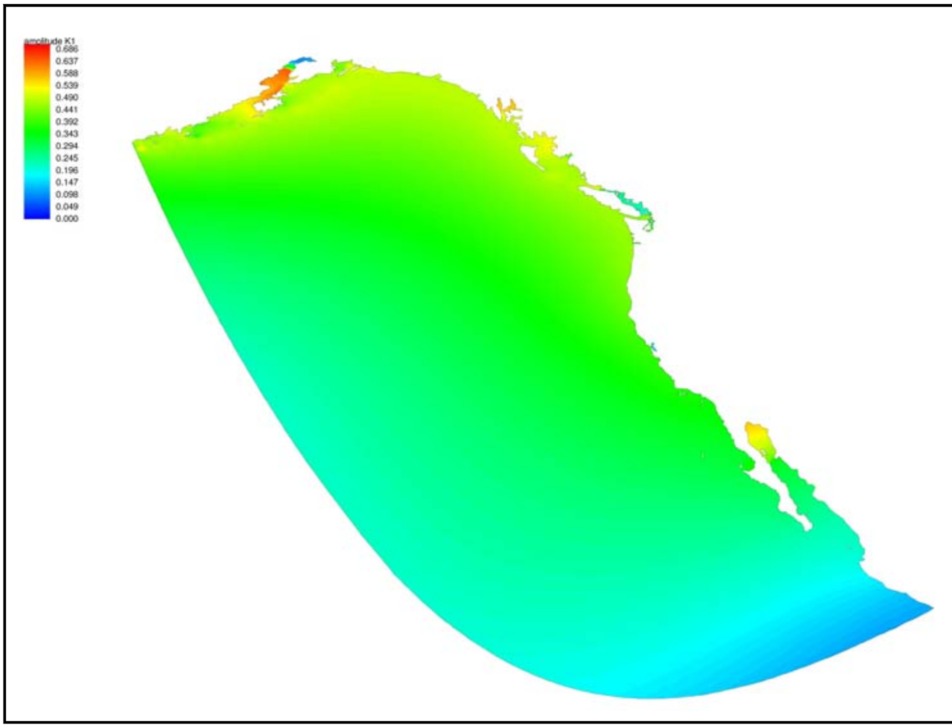
Courtesy of David Mark, ERDC, USACE

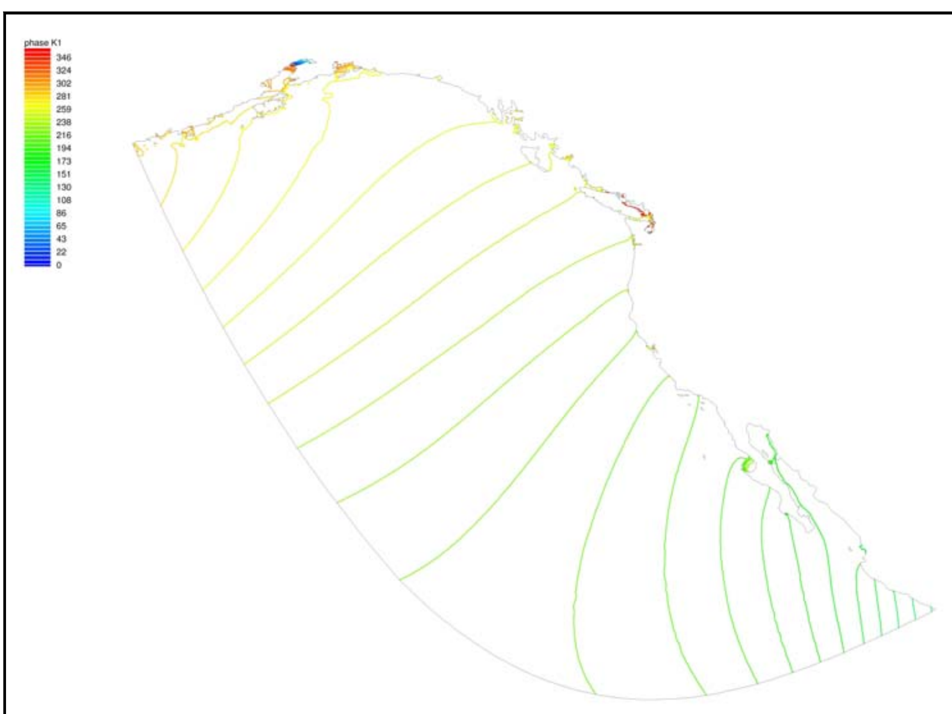
Eastern Pacific Tidal Model

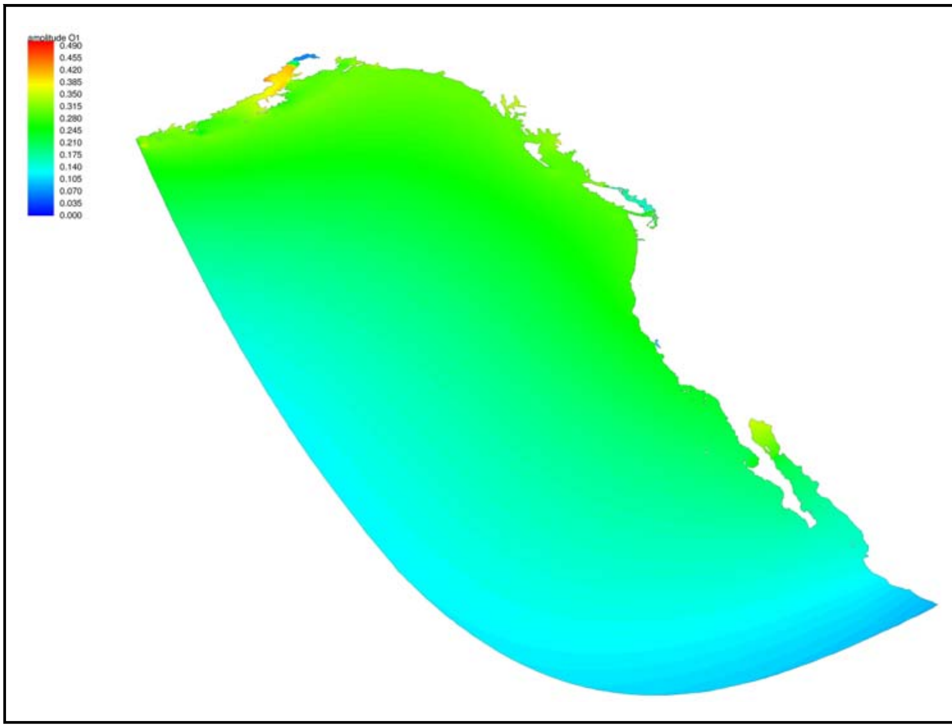


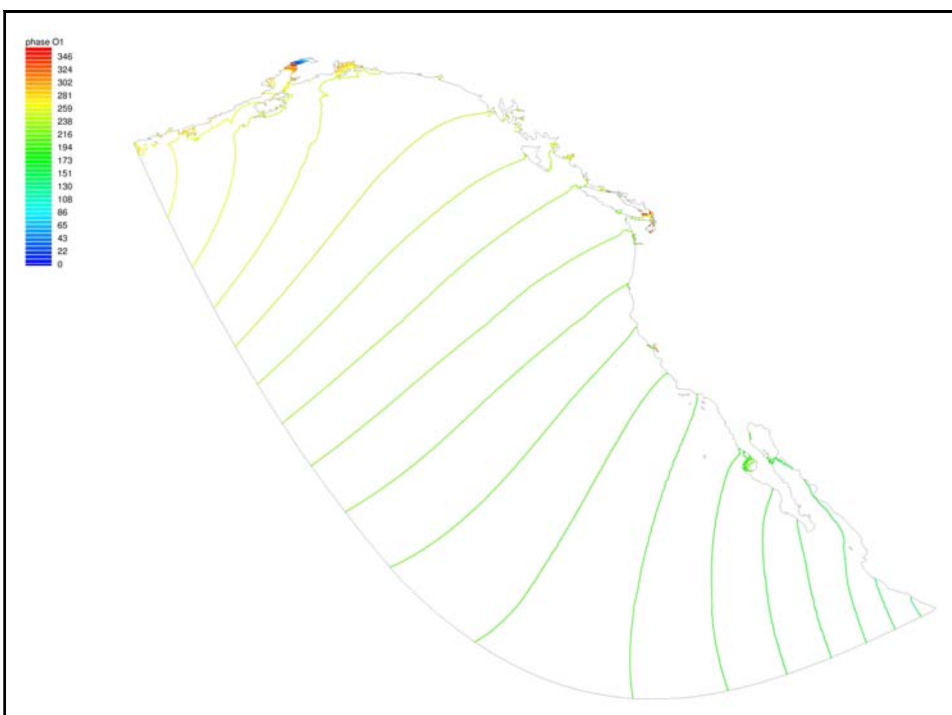
Eastern Pacific Tidal Model Bathymetry

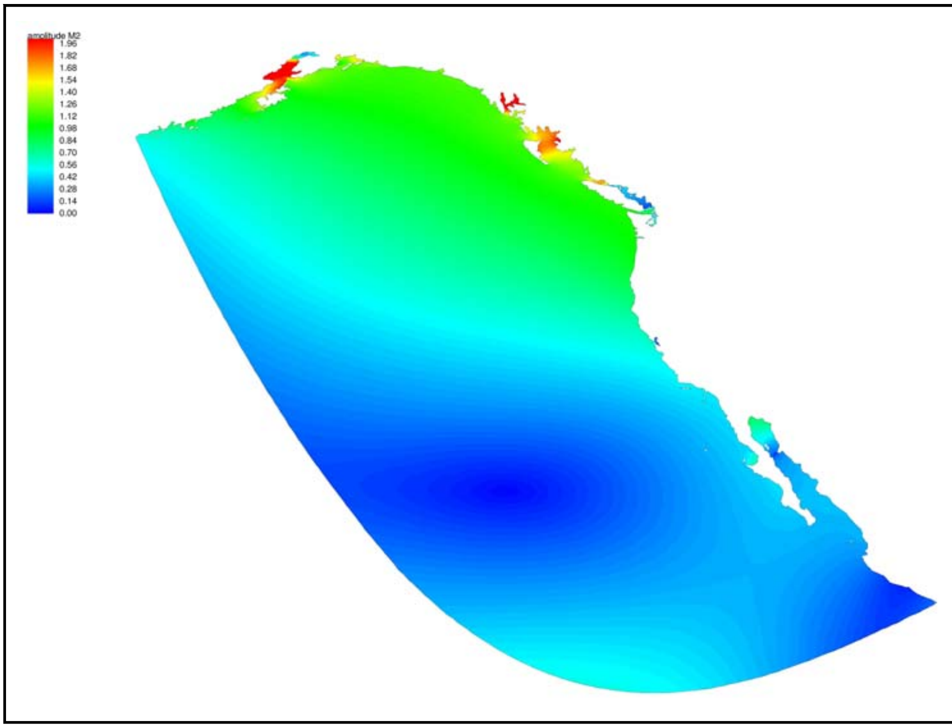


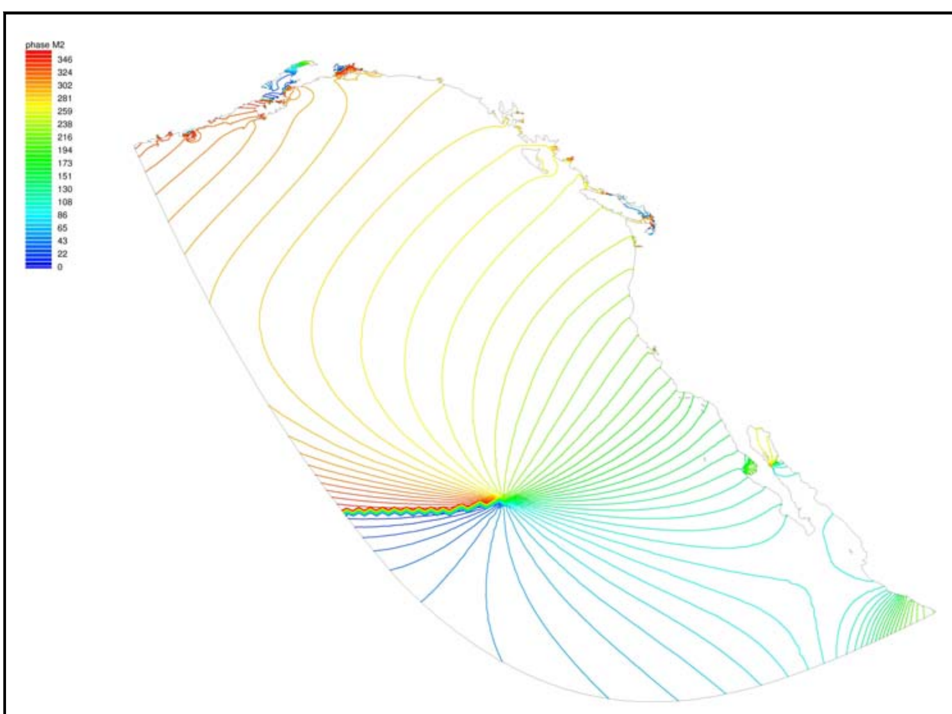

amplitude K1
0.686
0.637
0.588
0.539
0.490
0.441
0.392
0.343
0.294
0.245
0.196
0.147
0.098
0.049
0.000

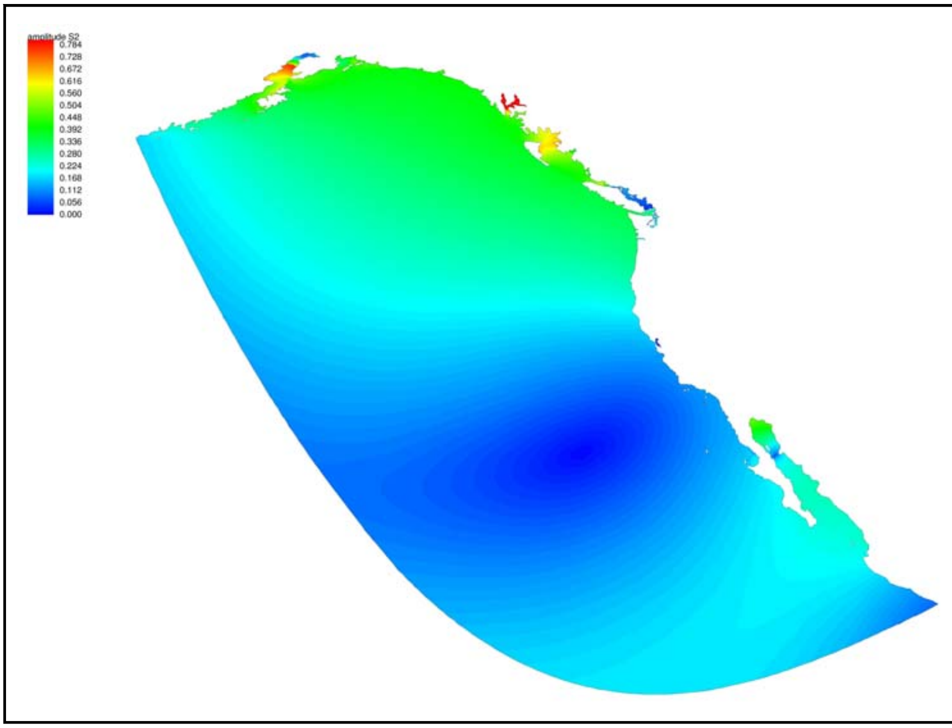

phase K1
346
324
302
281
259
238
216
194
173
151
130
108
86
65
43
22
0

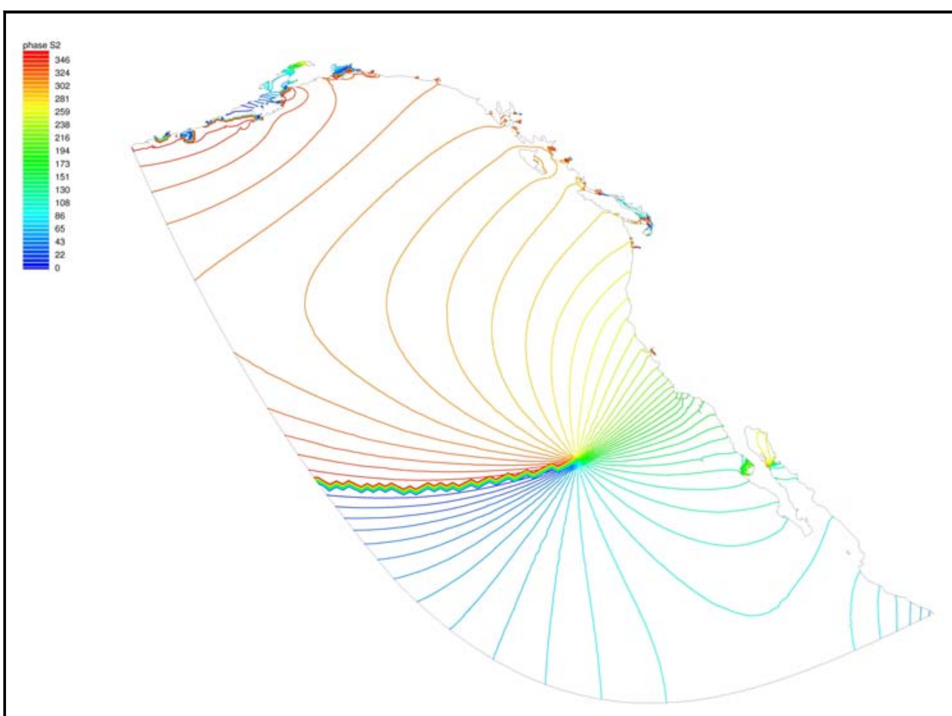

amplitude O1
0.490
0.455
0.420
0.385
0.350
0.315
0.280
0.245
0.210
0.175
0.140
0.105
0.070
0.035
0.000


phase O1
346
324
302
281
259
238
216
194
173
151
130
108
86
65
43
22
0


amplitude M2
1.96
1.82
1.68
1.54
1.40
1.26
1.12
0.98
0.84
0.70
0.56
0.42
0.28
0.14
0.00

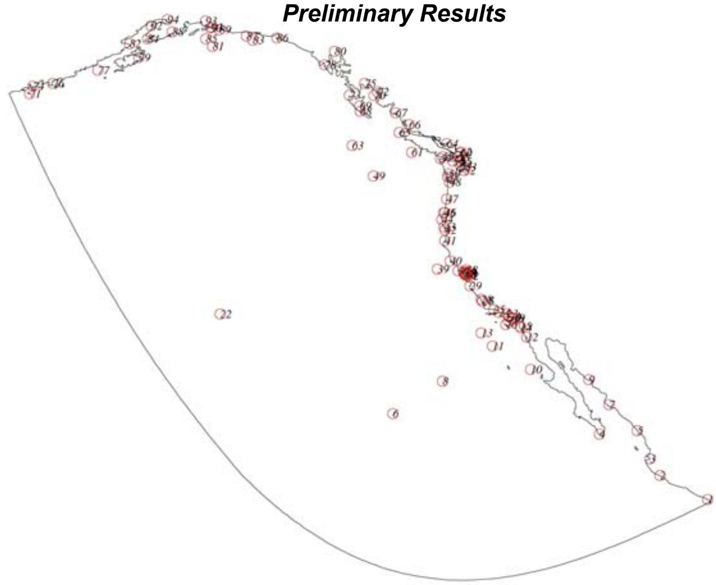

phase M2
346
324
302
281
259
238
216
194
173
151
130
108
86
65
43
22
0

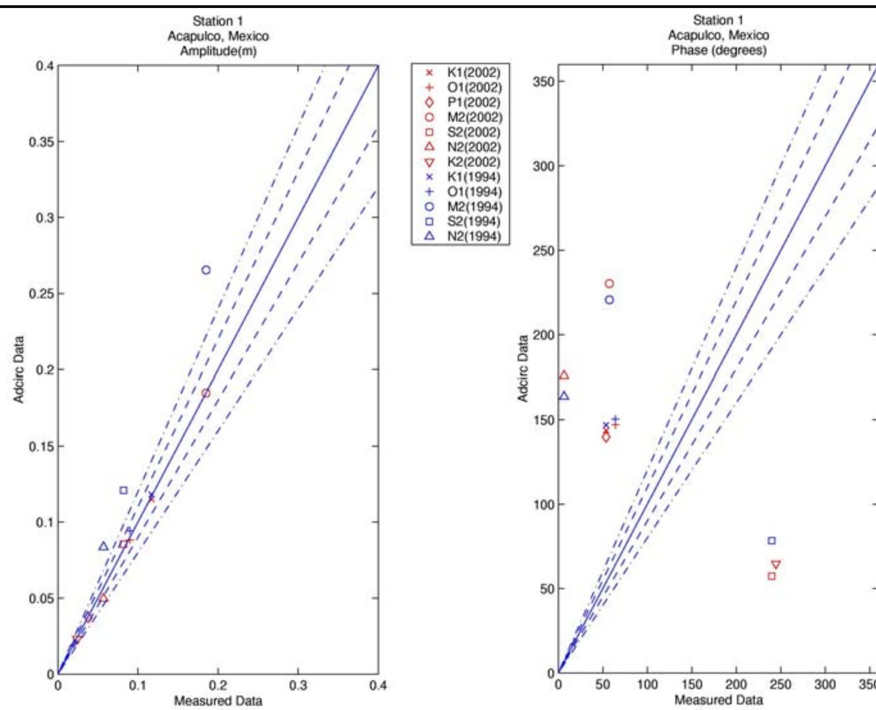

amplitude S2
0.784
0.728
0.672
0.616
0.560
0.504
0.448
0.392
0.336
0.280
0.224
0.168
0.112
0.056
0.000

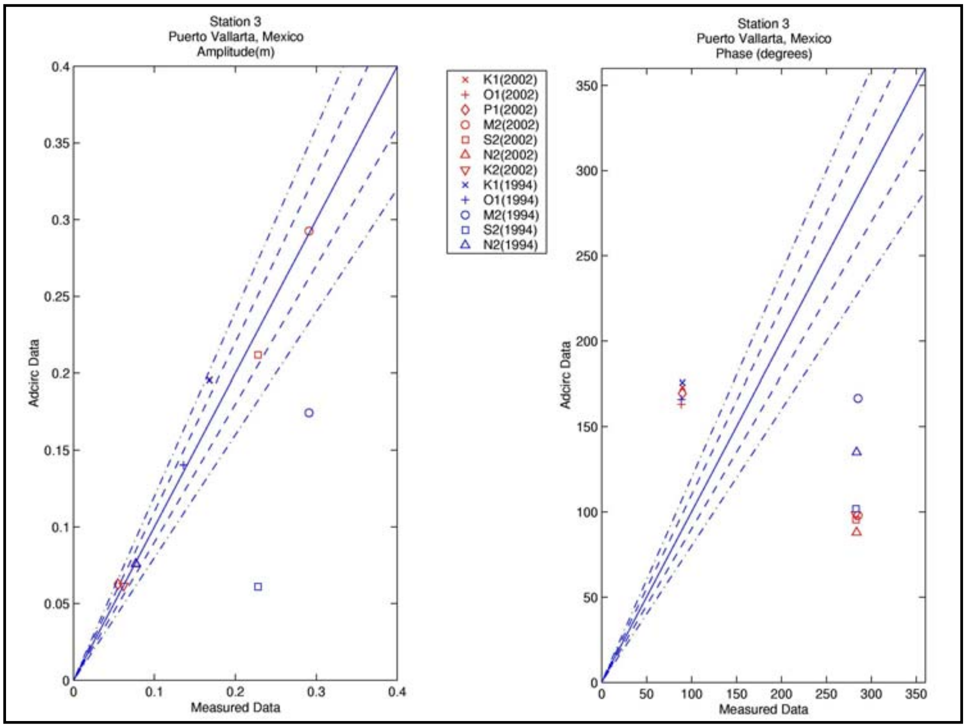

phase S2
346
324
302
281
259
238
216
194
173
151
130
108
86
65
43
22
0

Eastern Pacific Tidal Model Stations

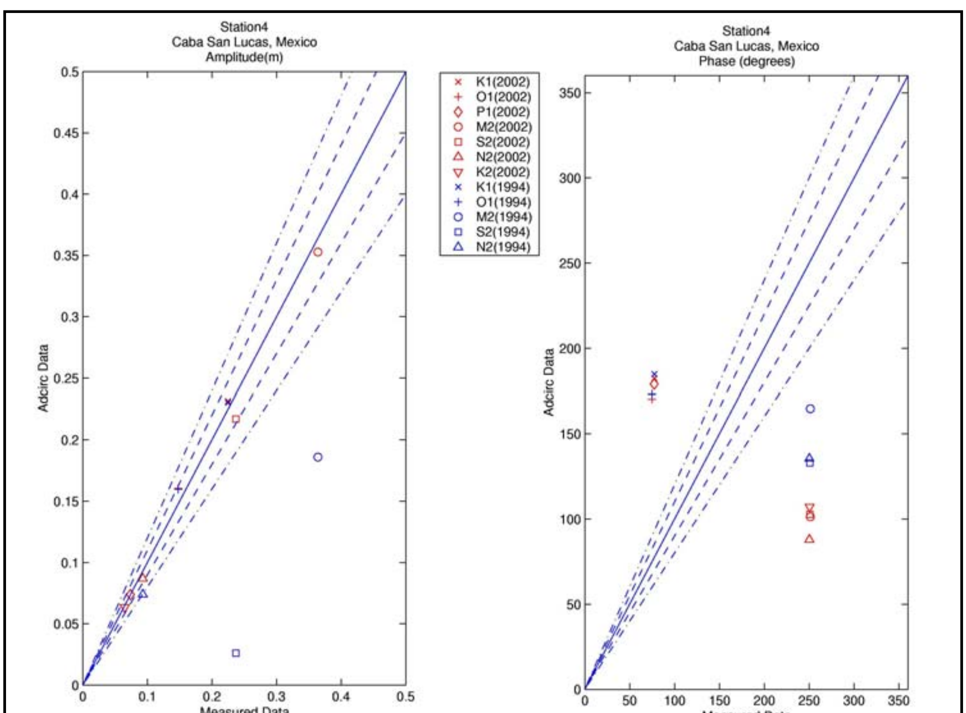
Preliminary Results



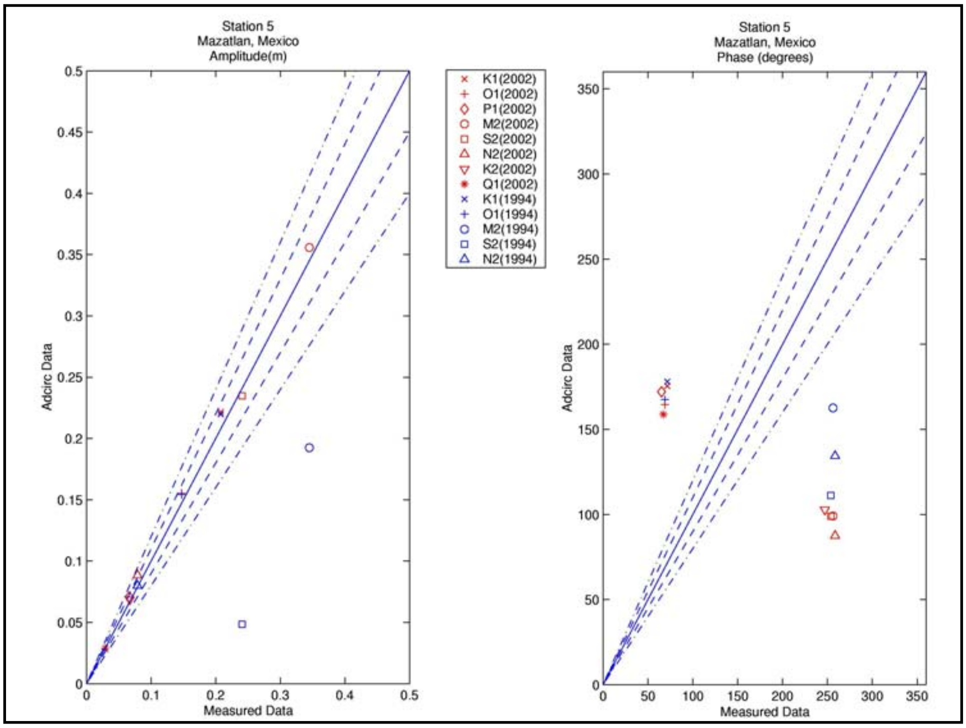


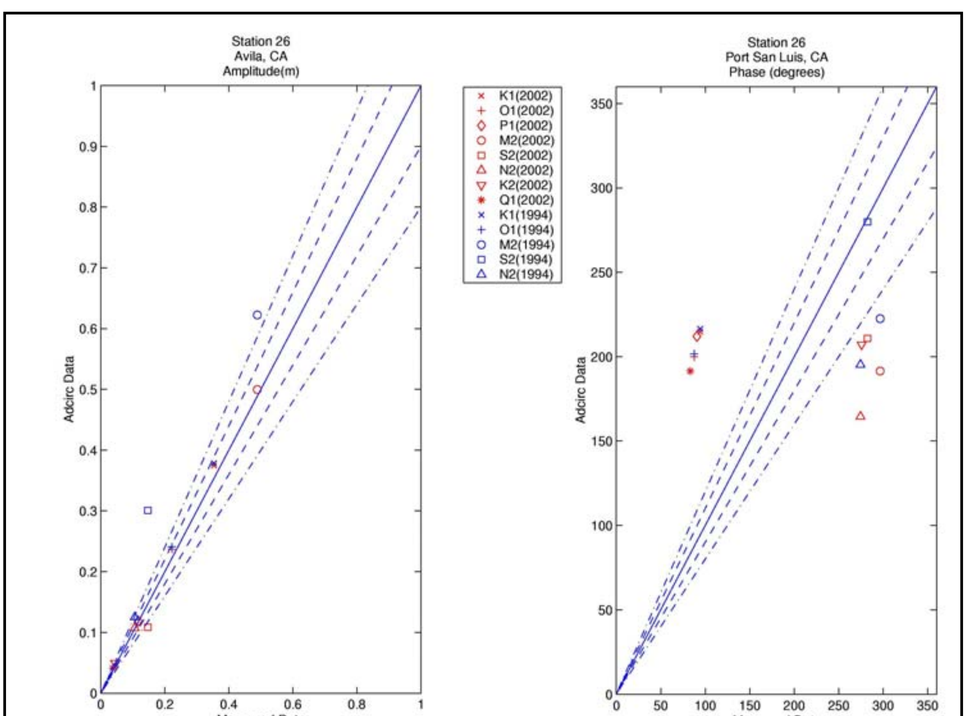


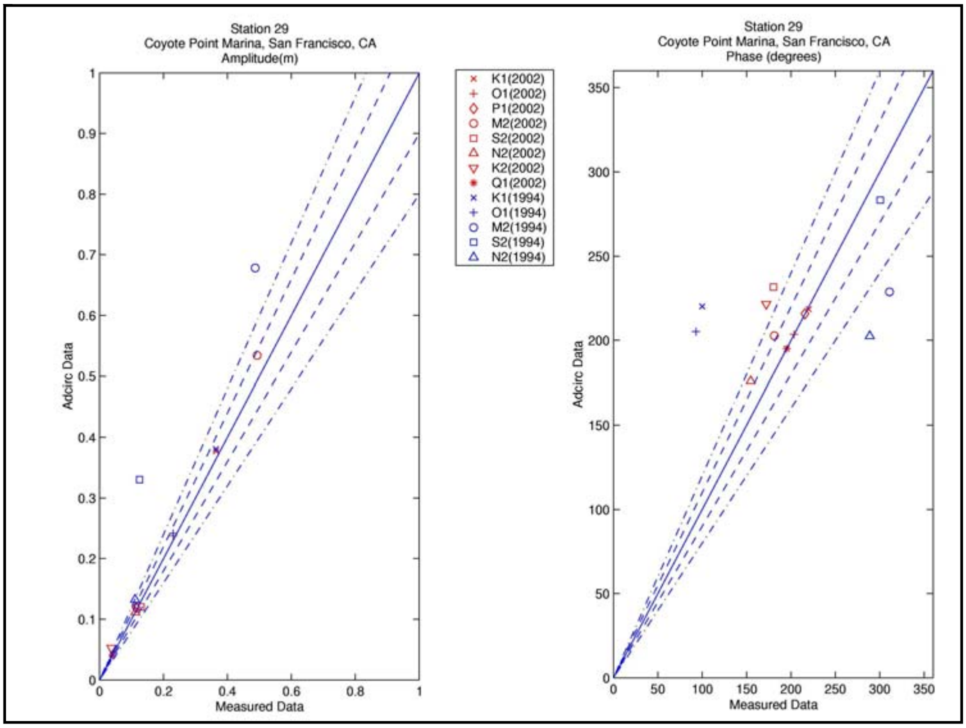
Station 3
Puerto Vallarta, Mexico
Amplitude(m)
Adcirc Data
Measured Data
K1(2002)
O1(2002)
P1(2002)
M2(2002)
S2(2002)
N2(2002)
K2(2002)
K1(1994)
O1(1994)
M2(1994)
S2(1994)
N2(1994)
Station 3
Puerto Vallarta, Mexico
Phase (degrees)



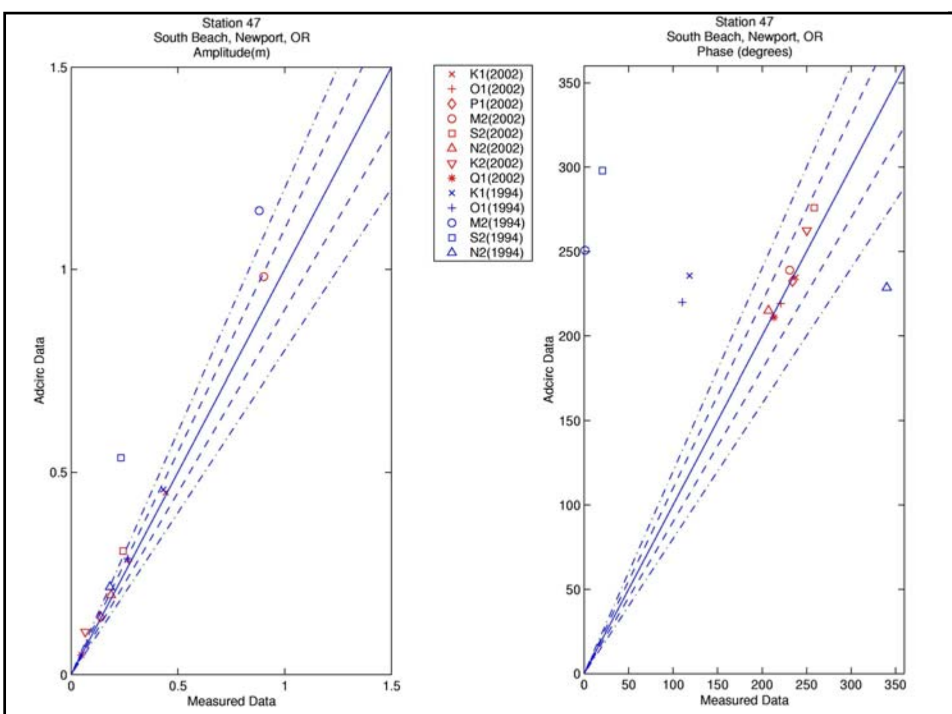
Station4
Caba San Lucas, Mexico
Amplitude(m)
Adcirc Data
Measured Data
K1(2002)
O1(2002)
P1(2002)
M2(2002)
S2(2002)
N2(2002)
K2(2002)
K1(1994)
O1(1994)
M2(1994)
S2(1994)
N2(1994)
Station4
Caba San Lucas, Mexico
Phase (degrees)


Station 5
Mazatlan, Mexico
Amplitude(m)
Adcirc Data
Measured Data
K1(2002)
O1(2002)
P1(2002)
M2(2002)
S2(2002)
N2(2002)
K2(2002)
Q1(2002)
K1(1994)
O1(1994)
M2(1994)
S2(1994)
N2(1994)
Station 5
Mazatlan, Mexico
Phase (degrees)
Adcirc Data
Measured Data

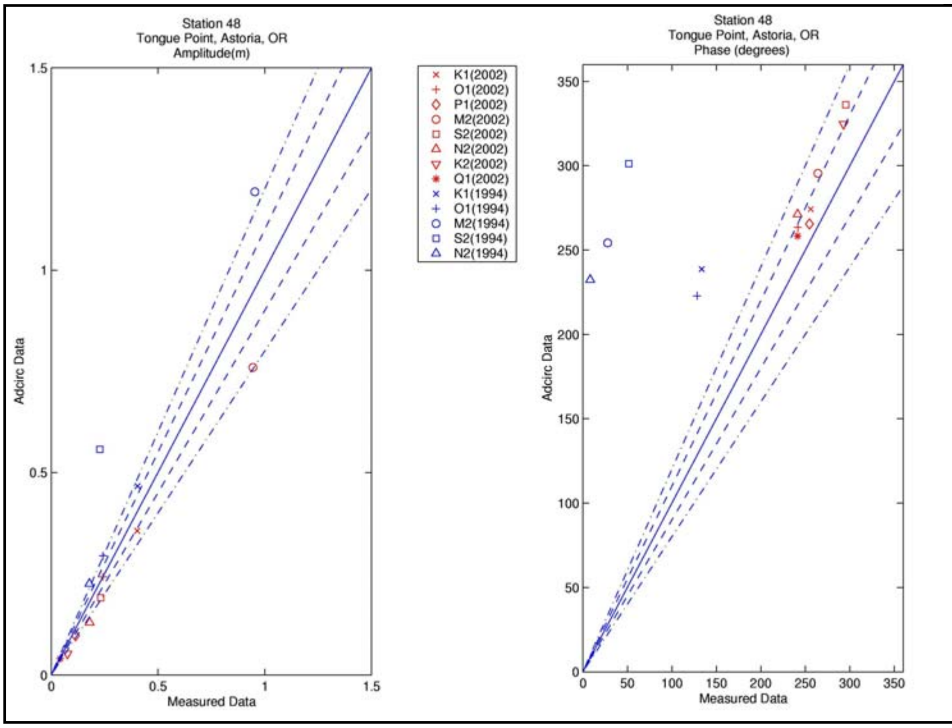

Station 26
Avila, CA
Amplitude(m)
Adcirc Data
Measured Data
K1(2002)
O1(2002)
P1(2002)
M2(2002)
S2(2002)
N2(2002)
K2(2002)
Q1(2002)
K1(1994)
O1(1994)
M2(1994)
S2(1994)
N2(1994)
Station 26
Port San Luis, CA
Phase (degrees)
Adcirc Data
Measured Data

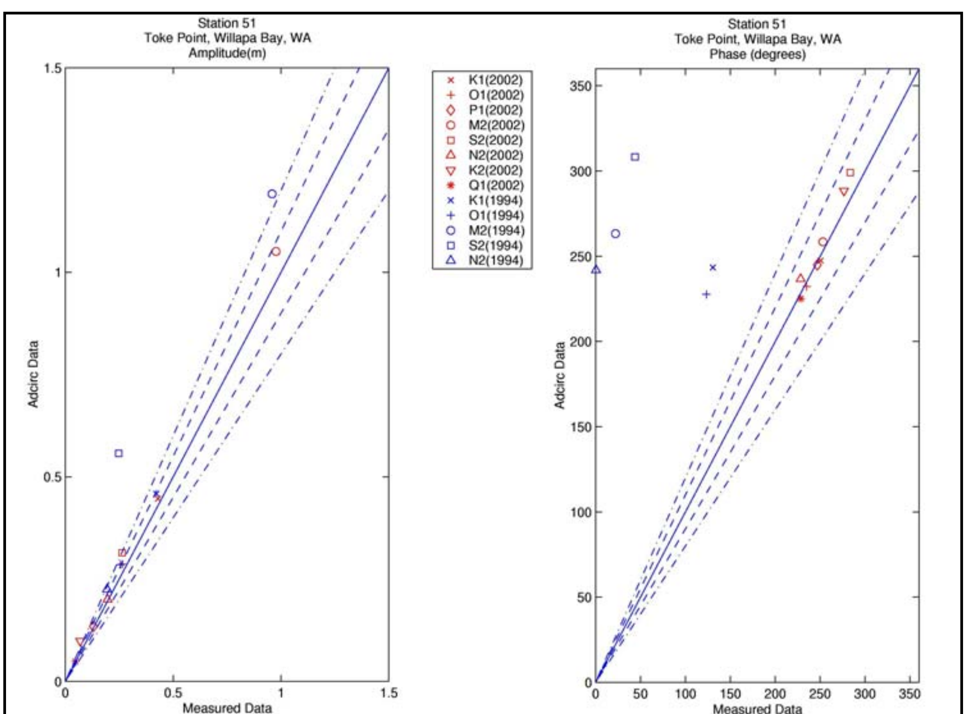


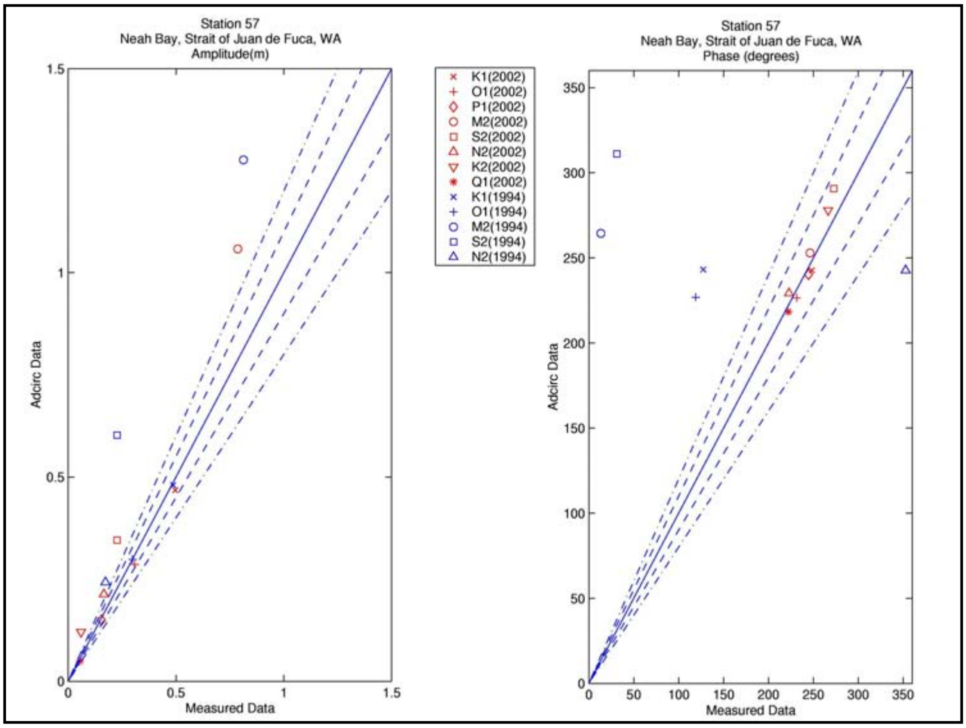
Station 29
Coyote Point Marina, San Francisco, CA
Amplitude(m)
Adcirc Data
Measured Data
K1(2002)
O1(2002)
P1(2002)
M2(2002)
S2(2002)
N2(2002)
K2(2002)
Q1(2002)
K1(1994)
O1(1994)
M2(1994)
S2(1994)
N2(1994)
Station 29
Coyote Point Marina, San Francisco, CA
Phase (degrees)
Adcirc Data
Measured Data

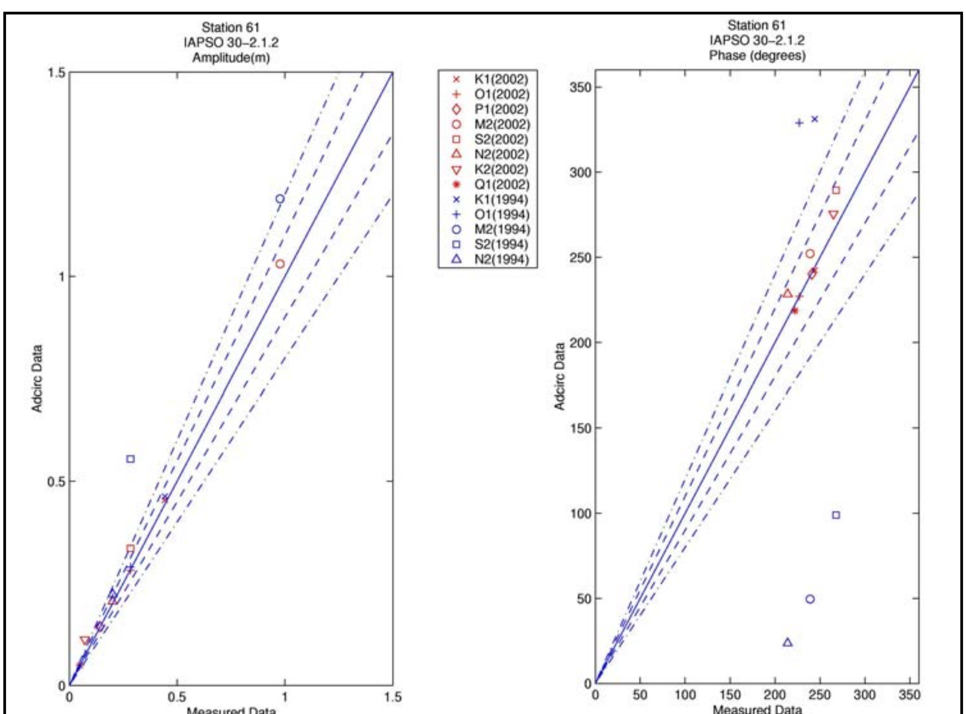


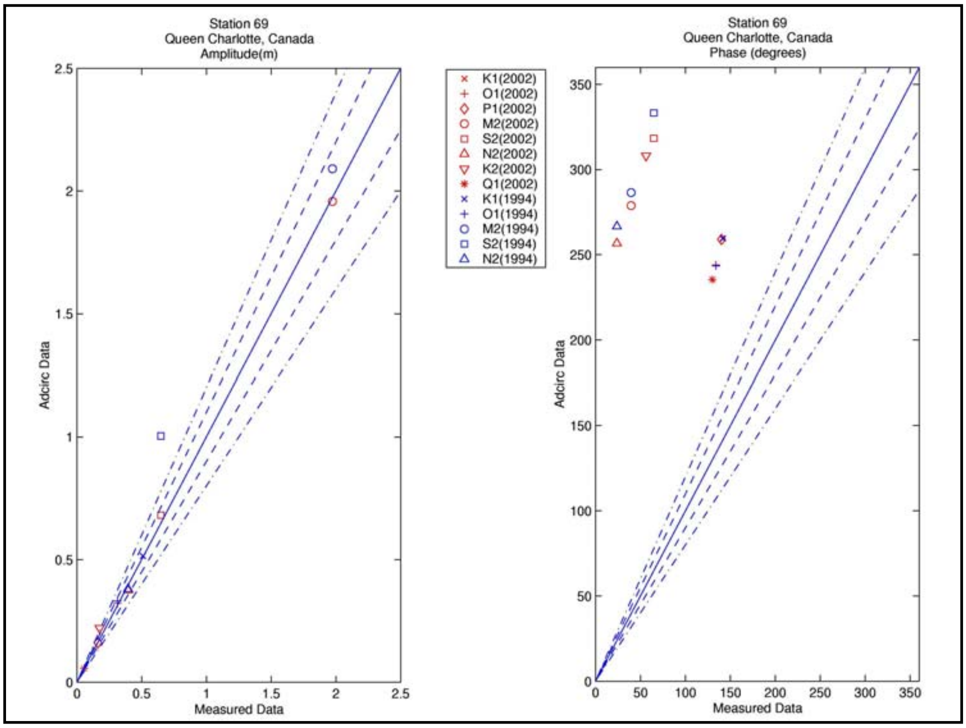
Station 47
South Beach, Newport, OR
Amplitude(m)
Adcirc Data
Measured Data
K1(2002)
O1(2002)
P1(2002)
M2(2002)
S2(2002)
N2(2002)
K2(2002)
Q1(2002)
K1(1994)
O1(1994)
M2(1994)
S2(1994)
N2(1994)
Station 47
South Beach, Newport, OR
Phase (degrees)
Adcirc Data
Measured Data

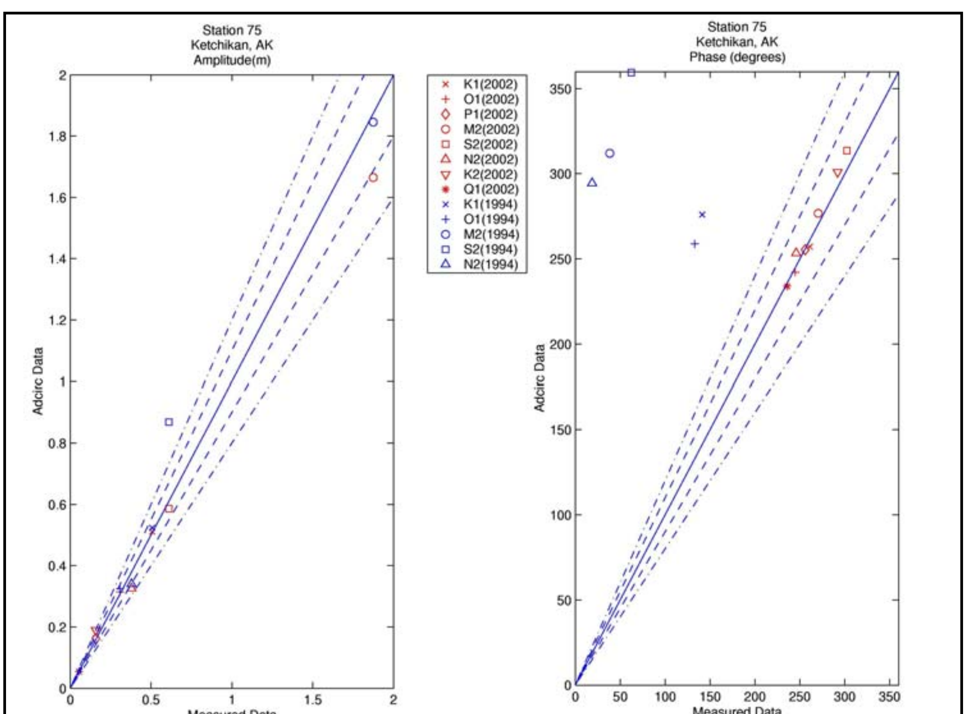

Station 48
Tongue Point, Astoria, OR
Amplitude(m)
Adcirc Data
Measured Data
K1(2002)
O1(2002)
P1(2002)
M2(2002)
S2(2002)
N2(2002)
K2(2002)
Q1(2002)
K1(1994)
O1(1994)
M2(1994)
S2(1994)
N2(1994)
Station 48
Tongue Point, Astoria, OR
Phase (degrees)
Adcirc Data
Measured Data

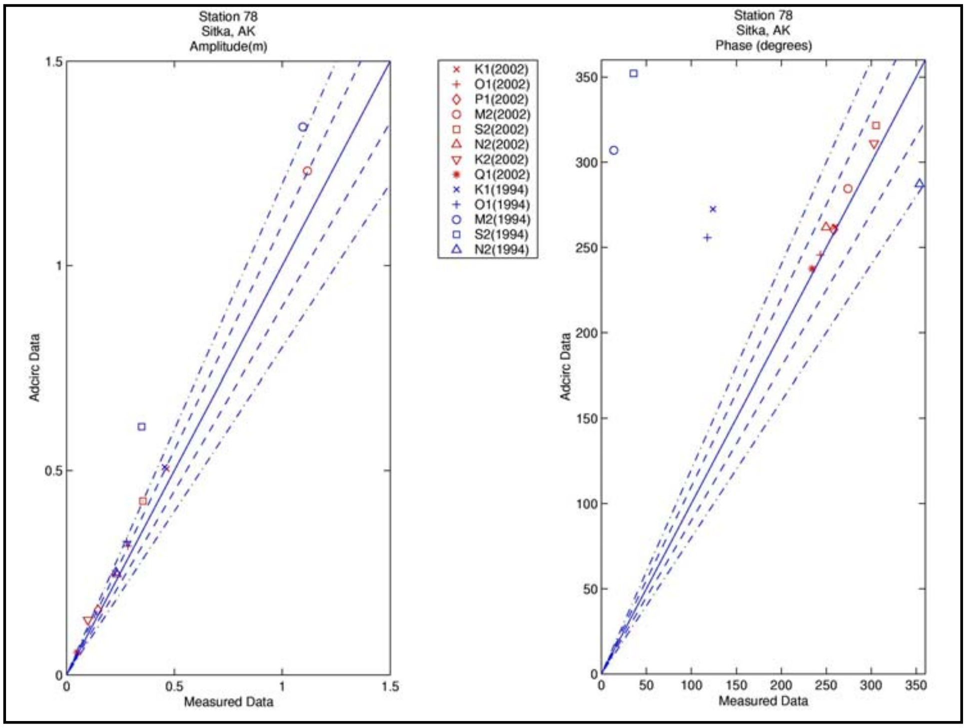

Station 51
Toke Point, Willapa Bay, WA
Amplitude(m)
Adcirc Data
Measured Data
K1(2002)
O1(2002)
P1(2002)
M2(2002)
S2(2002)
N2(2002)
K2(2002)
Q1(2002)
K1(1994)
O1(1994)
M2(1994)
S2(1994)
N2(1994)
Station 51
Toke Point, Willapa Bay, WA
Phase (degrees)
Adcirc Data
Measured Data


Station 57
Neah Bay, Strait of Juan de Fuca, WA
Amplitude(m)
Phase (degrees)
K1(2002)
O1(2002)
P1(2002)
M2(2002)
S2(2002)
N2(2002)
K2(2002)
Q1(2002)
K1(1994)
O1(1994)
M2(1994)
S2(1994)
N2(1994)
Adcirc Data
Measured Data

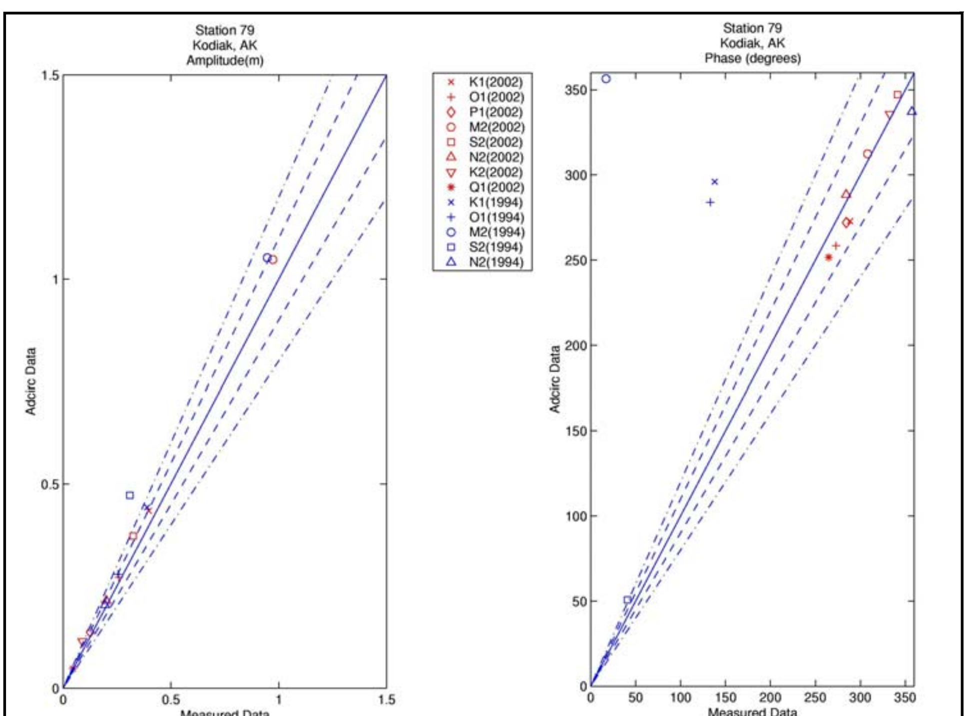

Station 61
IAPSO 30-2.1.2
Amplitude(m)
Phase (degrees)
K1(2002)
O1(2002)
P1(2002)
M2(2002)
S2(2002)
N2(2002)
K2(2002)
Q1(2002)
K1(1994)
O1(1994)
M2(1994)
S2(1994)
N2(1994)
Adcirc Data
Measured Data


Station 69
Queen Charlotte, Canada
Amplitude(m)
Adcirc Data
Measured Data
K1(2002)
O1(2002)
P1(2002)
M2(2002)
S2(2002)
N2(2002)
K2(2002)
Q1(2002)
K1(1994)
O1(1994)
M2(1994)
S2(1994)
N2(1994)
Station 69
Queen Charlotte, Canada
Phase (degrees)

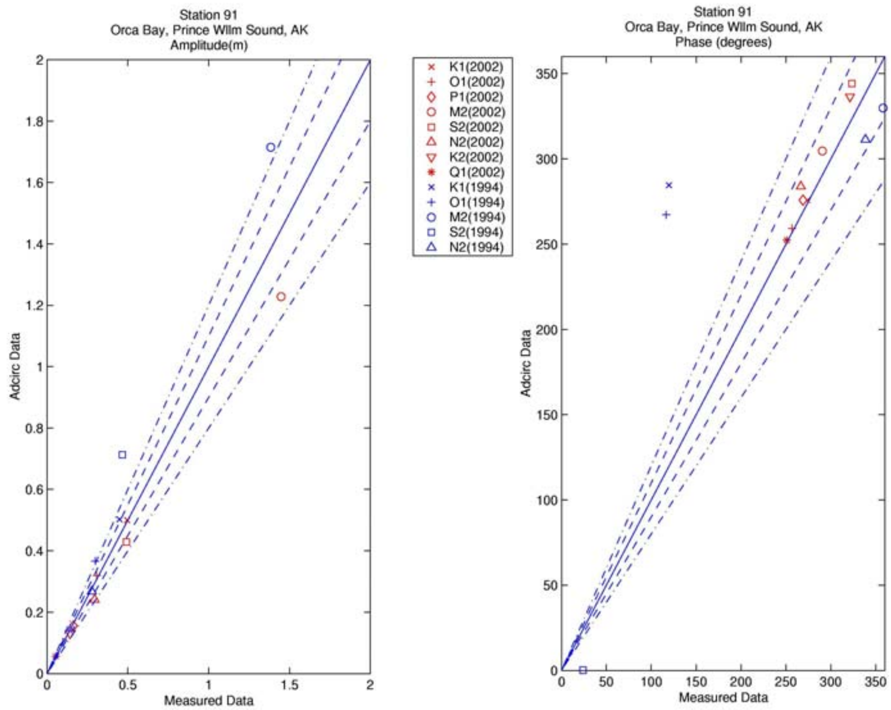

Station 75
Ketchikan, AK
Amplitude(m)
Adcirc Data
Measured Data
K1(2002)
O1(2002)
P1(2002)
M2(2002)
S2(2002)
N2(2002)
K2(2002)
Q1(2002)
K1(1994)
O1(1994)
M2(1994)
S2(1994)
N2(1994)
Station 75
Ketchikan, AK
Phase (degrees)



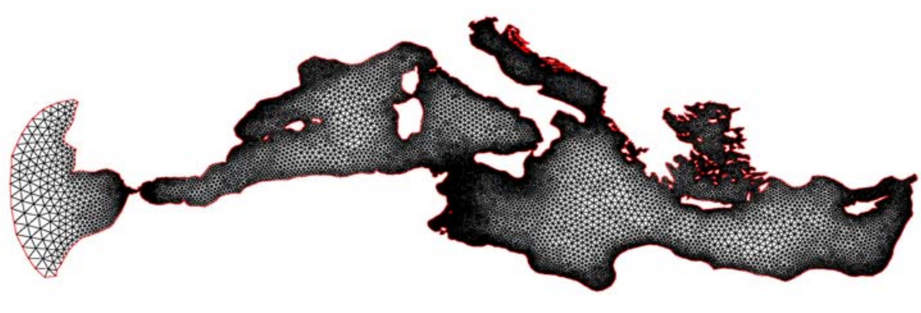
Station 78
Sitka, AK
Amplitude(m)
Adcirc Data
Measured Data
K1(2002)
O1(2002)
P1(2002)
M2(2002)
S2(2002)
N2(2002)
K2(2002)
Q1(2002)
K1(1994)
O1(1994)
M2(1994)
S2(1994)
N2(1994)
Station 78
Sitka, AK
Phase (degrees)



Station 79
Kodiak, AK
Amplitude(m)
Adcirc Data
Measured Data
K1(2002)
O1(2002)
P1(2002)
M2(2002)
S2(2002)
N2(2002)
K2(2002)
Q1(2002)
K1(1994)
O1(1994)
M2(1994)
S2(1994)
N2(1994)
Station 79
Kodiak, AK
Phase (degrees)

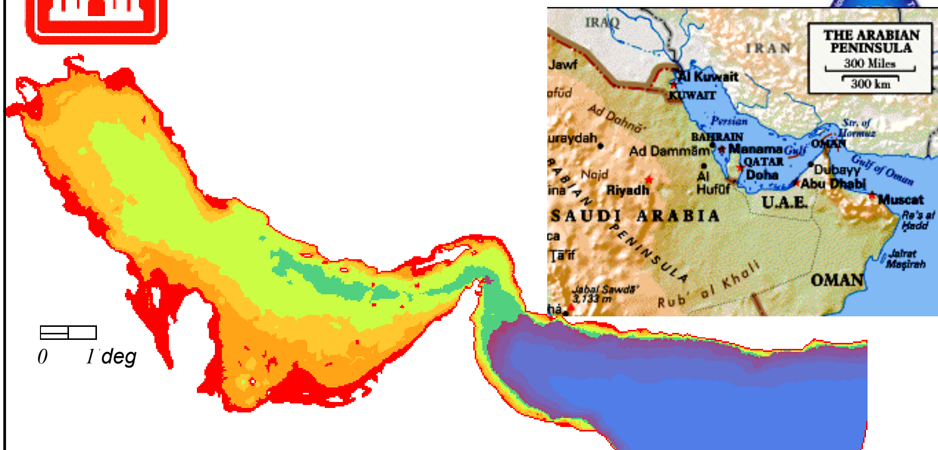


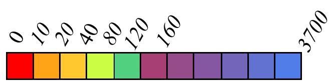
Mediterranean Sea Model



Courtesy of David Mark, ERDC, USACE

Persian Gulf Model



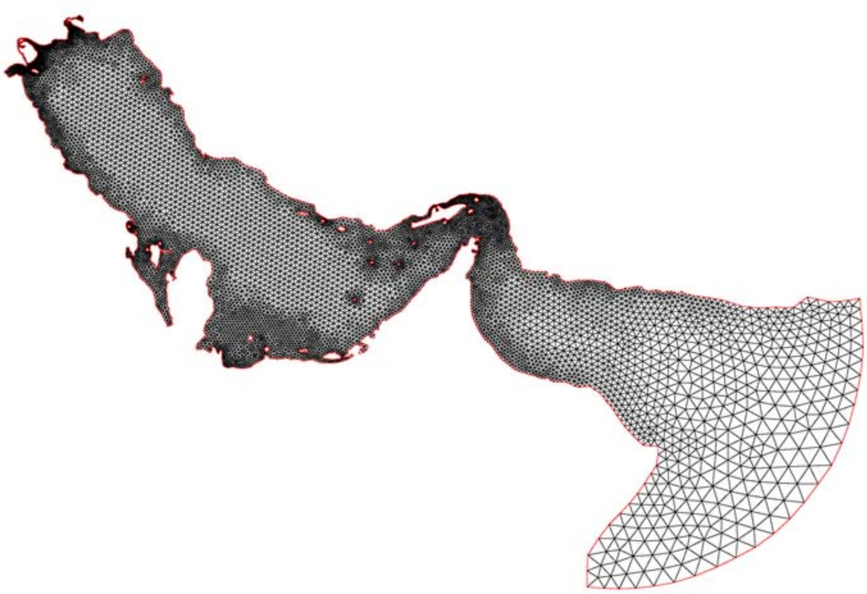


Bathymetry, (m)

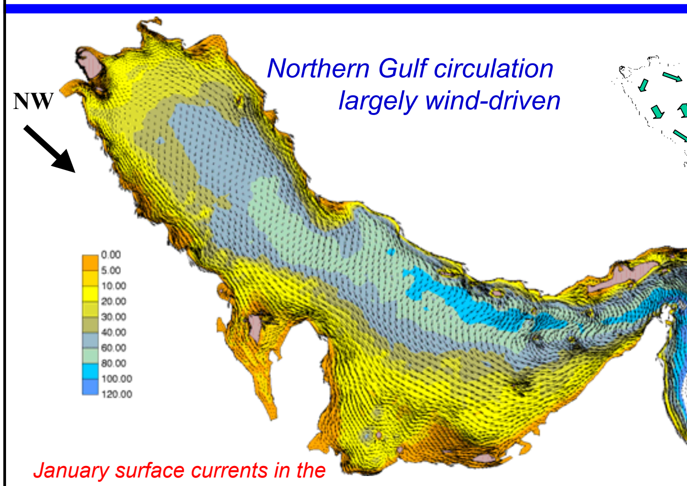
- *10 day simulation*
- *open ocean tidal forcing (Grenoble)*
- *DBDB-2 min bathymetry; enforce 10 m minimum depth*
- *parameters: bottom friction, vertical eddy viscosity coeff.*

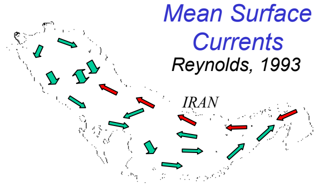
Courtesy of Cheryl Ann Blain, NRL, U.S. Navy

Persian Gulf Model



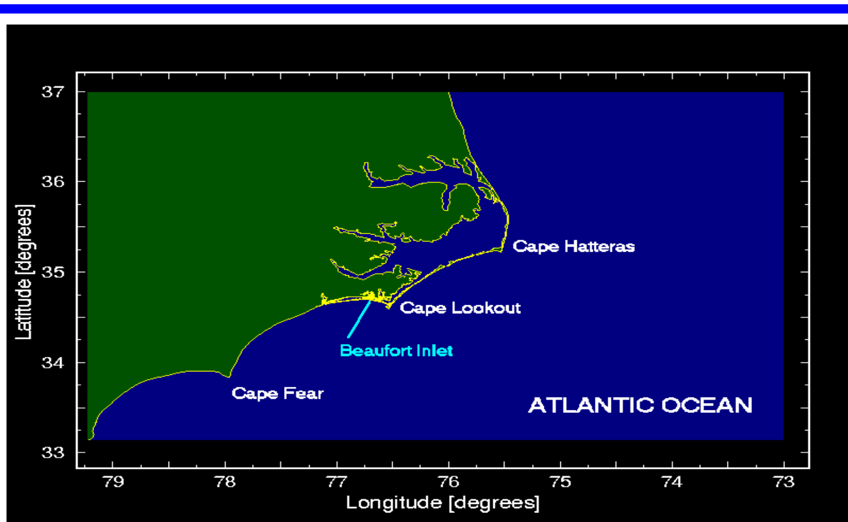
Persian Gulf 3D Wind-Driven Dynamics



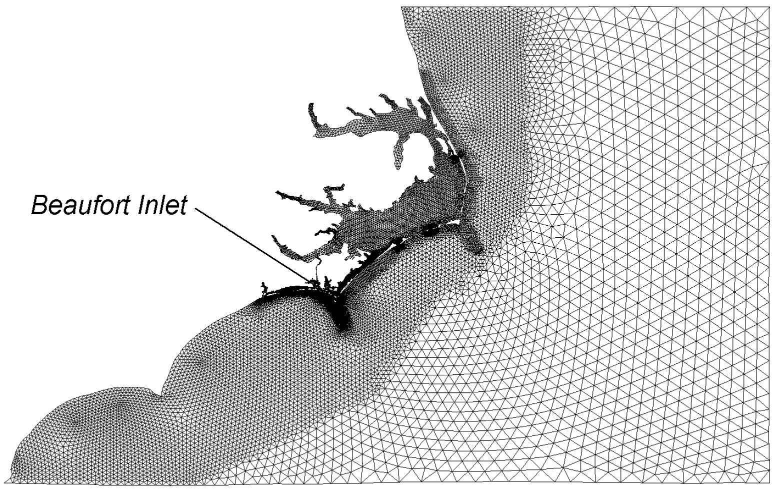


January surface currents in the Arabian Gulf

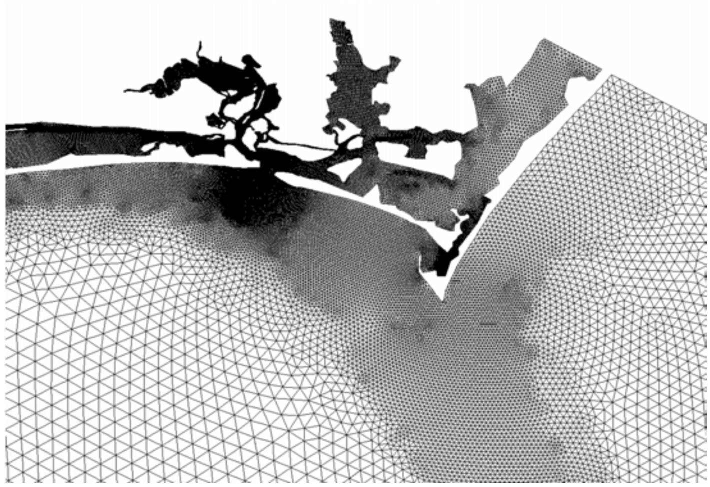
Beaufort Inlet Study – Larval Transport



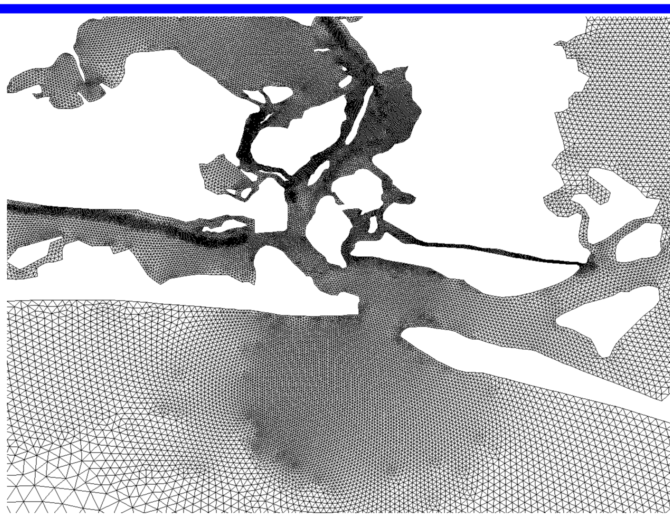
North Carolina Sounds Grid



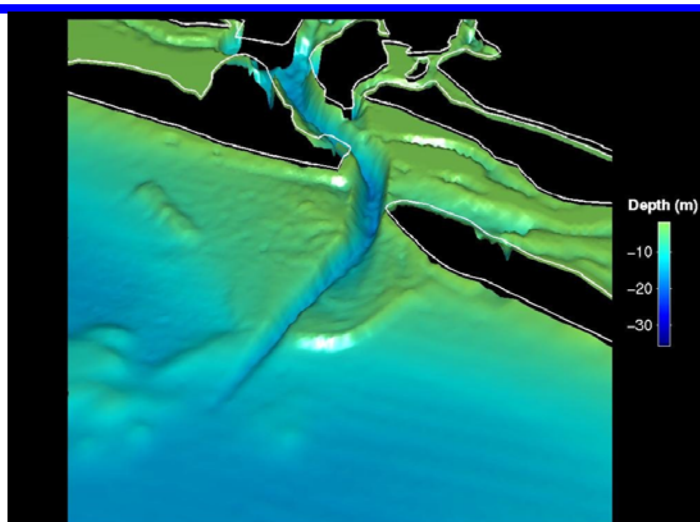
Beaufort Inlet Region – Zoom 1



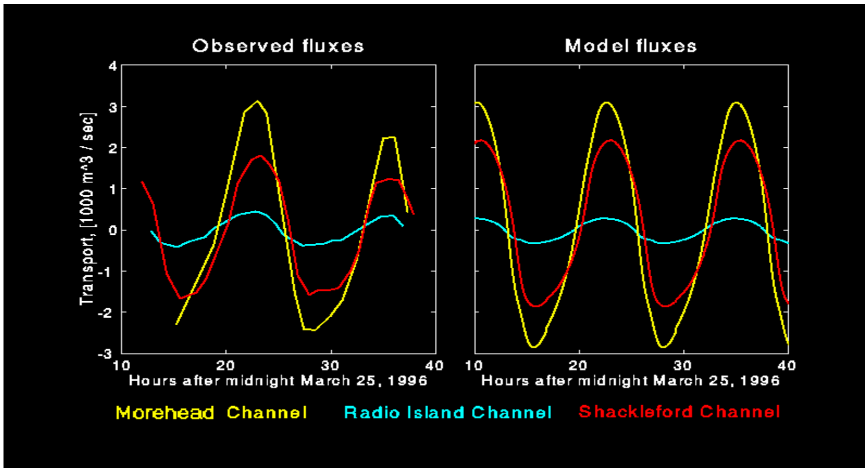
Beaufort Inlet Region



Beaufort Inlet Bathymetry



Beaufort Inlet Study

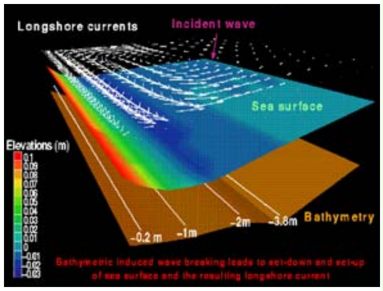


Beaufort Inlet Experiment – Larval Transport

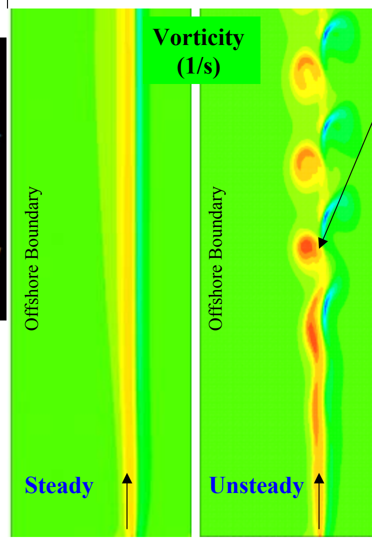
- Movie….

Simulation of a Longshore Currents

One-Way Wave-Circulation Coupling



Bathymetric-induced wave breaking leads to a longshore current parallel to the shoreline.



Longshore current

Circulation vortices appear in the unsteady circulation and are advected with the longshore current.

The unsteady longshore current is classified as a shear wave.

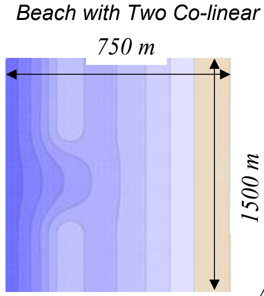
Instabilities and shear waves are a mechanism for lateral mixing.

Courtesy of Cheryl Ann Blain, NRL, U.S. Navy

Simulation of a Rip Current

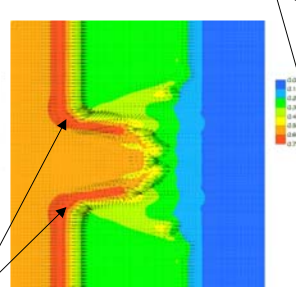
One-Way Wave-Circulation Coupling

Beach with Two Co-linear Bars



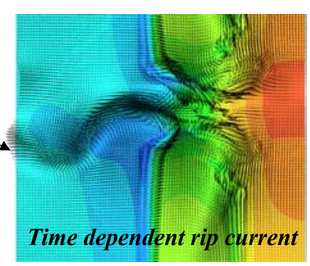
Bathymetry

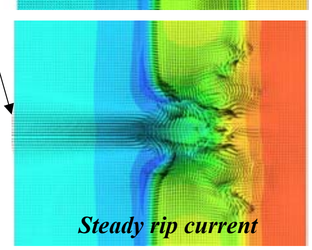
Rip Current



Wave Breaking

Wave Heights
Gradients of Radiation Stress





Sea Surface Elevation
Depth-Averaged Currents

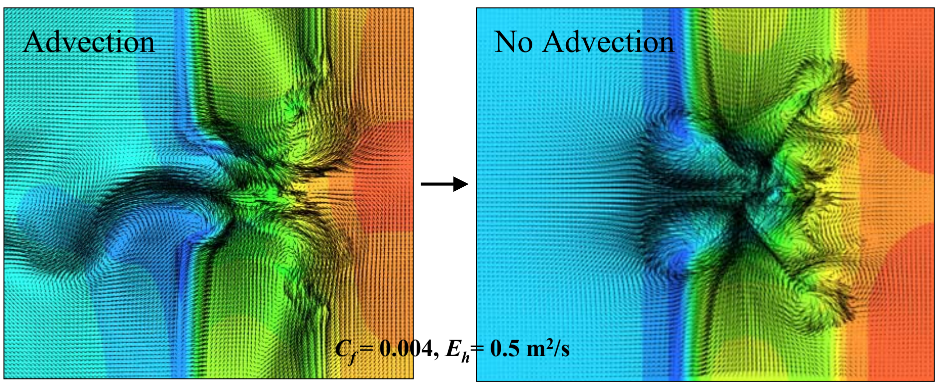
Beach Slope = 0.009
Incident Wave Height = 1.0 m
Period = 10 sec
Normal Incidence

Role of Advection

Unsteady advective rip current moves in response to advection created by vortex circulation.

Eliminating advective terms results in a steady state solution and drastically alters the rip current offshore advection.

Computed Sea Surface Elevation and Current Velocity



Summary

- ADCIRC simulates a wide-variety of hydrodynamic problems
- ADCIRC allows
  - Flexible domains to simplify boundary condition specification
  - Localized grid resolution to ensure accuracy while optimizing computational cost
- Bathymetry and boundary condition specification are critical to good solutions
- For more information, see the ADCIRC web site:

  www.marine.unc.edu/C_CATS/adcirc